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S. HRG. 101-32

NATIONAL GLOBAL CHANGE RESEARCH ACT OF 1989

HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

S. 169

TO AMEND THE NATIONAL SCIENCE AND TECHNOLOGY POLICY, ORGANIZATION, AND PRIORITIES ACT OF 1976 IN ORDER TO PROVIDE FOR IMPROVED COORDINATION OF NATIONAL SCIENTIFIC RESEARCH EFFORTS AND TO PROVIDE FOR A NATIONAL PLAN TO IMPROVE SCIENTIFIC UNDERSTANDING OF THE EARTH SYSTEM AND THE EFFECT OF CHANGES IN THAT SYSTEM ON CLIMATE AND HUMAN WELL-BEING

FEBRUARY 22, 1989

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THE NATIONAL GLOBAL CHANGE RESEARCH ACT OF 1989

WEDNESDAY, FEBRUARY 22, 1989

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The committee met, pursuant to notice at 9:30 a.m., in room SR-253, Russell Senate Office Building, Hon. Ernest F. Hollings (chairman of the committee) presiding.

Staff members assigned to this hearing: Penny Dalton and Mike Nelson, professional staff members; and Sherman Joyce, minority staff counsel.

OPENING STATEMENT BY THE CHAIRMAN

The CHAIRMAN. Good morning. The committee will please come to order. We are pleased this morning to initiate our hearings on S. 169, our bill to coordinate the government's research with respect to global change and to require annual recommendations and reports to the Congress on what we should be doing about it.

Let me welcome all of you to today's hearing on the greenhouse effect and global change. Years ago, Will Rogers remarked that everybody complains about the weather but nobody does anything about it. Our task, heading into the 1990's, is to prove Will Rogers wrong. We are gathered this morning not just to complain about the dangers of global climate change, but also to talk about what we can and must do to reverse mankind's current perilous course.

Few dispute the fact that the Earth's climate is changing perceptibly and—relatively speaking—rapidly. In the past year, the world's consciousness has been jolted by droughts, floods, and heat waves of historic magnitude. We ignore these events and trends at our own peril.

On that score, I am personally committed to seeing that this Congress leads the way in studying the causes of global climate change, and in mobilizing an international response. I know that many of my colleagues share that sense of commitment and look forward to working with them in the months to come. In addition, Secretary Baker's recent remarks show a new openness by the Bush administration in addressing this issue. I welcome Secretary Baker's call to action because the worldwide implication of climate change must transcend traditional political and national rivalries.

This morning, in reviewing S. 169, the National Global Change Research Act, we undertake the first important step in what must be a sustained, long-term focus on this critical challenge.

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However, before discussing the particulars of S. 169, permit me to give a brief overview of the nature of the problem that confronts us. The bottom line really is that—through population growth, industrialization, and energy use—mankind is changing the global environment. In recent years, scientists have observed major changes in the Earth's atmosphere, oceans, and land masses. These changes include rising world temperatures, shifts in climate zones, depletion of the stratospheric ozone layer that shields the planet from harmful radiation, and possible rises in sea levels. If these global changes continue, they will have profound and lasting effects on many aspects of life. Steady increases in world temperatures could create drought and dust bowl conditions in many areas of the world. Depletion of stratospheric ozone could lead to thousands of new cases of skin cancer each year. Rising sea levels could permanently flood many coastal communities.

Scientists believe that human activities, such as the burning of fossil fuels, the use of certain chemicals, and the massive destruction of forests, have contributed to these new global changes. In some cases, existing scientific knowledge of these events is adequate to allow policy makers to make sound decisons. For example, last year, the known relationship between chlorofluorocarbons [CFC's] and the depletion of the stratospheric ozone layer led to ratification of the Montreal Protocol to limit production, emission, and trade of these compounds. Domestic regulations also have been proposed to restrict the use of CFC's.

Major scientific uncertainties exist, however, regarding many aspects of global change. One of the most pressing concerns at the present time is the "greenhouse effect", the warming of the Earth's surface by solar energy which is trapped by gases in our atmosphere. The greenhouse effect is a naturally occurring phenomenon resulting from water vapor and carbon dioxide which normally are present in the Earth's atmosphere. Without this natural greenhouse warming, the Earth would be about 60 degrees cooler than it is, and life, as we know it, would not be possible. However, over the past century, the concentration of manmade greenhouse gases in the atmosphere has jumped sharply as a result of combustion, deforestation, and industrial activities. This accumulation of greenhouse gases is expected to increase the heat trapped by the Earth's atmosphere and world temperatures could increase by several degrees. About half of this projected greenhouse warming is caused by carbon dioxide. Methane, nitrous oxide, ground-level ozone and CFC's together account for the other half.

Detecting the onset of greenhouse warming and predicting its consequences presently are the subject of intense scientific debate. For example, scientists are uncertain whether the drought in the Midwest and heat wave of the summer of 1988 were one-time events or are part of a long-term shift toward hotter, drier summers. Some researchers have suggested that greenhouse warming is already under way. In this decade, we have experienced the 4 hottest years since the 1880's. Although not conclusively linked to long-term climate change, the drought and heat wave have focused public attention on the potential implications of such change. Both highlight a growing need for rigorous scientific assessment of the effects of human activity on the global environment.

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Balancing the need for better information, the most reasonable course of action is to prevent problems which we can anticipate now, rather than waiting until they become critical. A wide range of policy options has been proposed, including enhanced fuel efficiency and energy conservation, development of renewable energy sources, improved land-use policies, and increased emphasis on sustainable development.

Interest in the issue has not been confined to the United States. In 1987, the World Commission on Environment and Development produced the report, "Our Common Future," calling for international action to reverse long-term global environmental trends. The report recommends establishment of strategies to reduce energy consumption, increase scientific and renewable energy research, and improve the transfer of technologies to developing nations.

A few months ago, the World Meteorological Organization and the United Nations Environment Program brought together delegates from 30 nations to initiate an Intergovernmental Panel on Climate Change [IPCC]. At their first meeting in Geneva, the IPCC established three working groups to address the climate problem. The United States will head the third group, with responsibility to formulate response strategies for mitigating or adapting to climate change. The group, chaired by Assistant Secretary of State Bernthal, met earlier this month to adopt an agenda. At that meeting, Secretary of State Baker called for international action to counter the threat of global warming through reduced emissions, improved energy efficiency, and reforestation. Secretary Baker's position provides a welcome change from the Reagan administration's emphasis on the need for more research before taking action.

This worldwide interest convinces me, that despite the ominous trends we have observed over the past decade, there remains tremendous cause for optimism. I maintain my confidence in the ability of mankind to find solutions to the complex environmental challenges that face us.

Finding those solutions will require an improved understanding of how our fragile planet works. And scientists around the world are rising to the challenge of providing that understanding. An extraordinary range of research activities is already underway, involving scientists from many different backgrounds and tapping the most advanced satellites, instruments, and computer technology. We must now give organization and coordination to these efforts, particularly here in the United States.

The bill I introduced on January 25, the National Global Change Research Act, mandates Federal planning to study long-term global problems such as greenhouse warming and ozone depletion. It calls for improved coordination of interagency research and requires development of a 10-year National Global Change Research Plan. The bill strengthens ongoing efforts at the Federal Coordinated Council for Science, Engineering, and Technology [FCCSET] to establish a national program. FCCSET is also charged with developing federal research priorities and coordinating agency budgets.

The United States is presently the world leader in global-change research, with our Federal Government spending many millions of dollars. As the challenges of global change become better defined, Federal spending on associated research is expected to expand.

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With increases in the size and number of programs, planning and coordination will be vital for allocating funds in the most effective way possible, as well as preventing duplication of agency efforts.

Solutions to global environmental problems will come neither easily nor cheaply. But with a determined and coordinated effort, both here in the United States and in other nations, we can get the job done.

I welcome each of you here today. I am confident that you all share my sense of urgency and commitment.

Everyone is going off in all directions. Last week in my own home state, I heard that President Bush told an old friend of mine aboard ship during the war when in danger, when in doubt, run in circles, scream and shout.

And we are all going off in all directions. S. 169 is an attempt to formalize the efforts of the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) in the White House, so that they can coordinate, the research of the various departments and agencies and outline the budget requirements.

We already have spent millions and millions of dollars at the federal level, but we see tremendous duplication and lack of coordination. Annual reports to this committee, in particular to Senator Gore as the chairman of our subcommittee and a leader in this field, will ensure that we know exactly what is in order.

I would simply add that just a couple of months ago, I had the pleasure to be on the ice in Antarctica, and looking up at the sun 24 hours a day. A fellow was there from the University of Rome and said—listen to the bells ringing in the sun. So I stuck my ear down there. I am not sure I heard bells, but you could see the fluctuations on his computer.

But the significant thing, and I think Senator Gore would agree, was up on the Newell Glacier at 30 below, where the scientists were taking ice cores. Dr. Corell, Paul Mayewski was one member of the group from the University of New Hampshire. He had also been there some ten years before.

The ice core was about 18 feet long and was laid down over 240,000 years. Scientists were measuring each millimeter, and about 25 to 22 years ago you could see the discoloration in the ice. Now, I am no scientist and I cannot say scientifically that is when we started releasing chlorofluorocarbons and those kinds of things, but it certainly impressed me. And there is no doubt about the seriousness of the problem now.

Secretary Baker recently addressed an international group and has asked for action, and you know us politicians. We are ready to act, but we want to act intelligently. A number of research agencies will be involved. We have the National Oceanic and Atmospheric Administration. We have NASA and others. Several committees, the Environment Committee, Governmental Affairs and others, are also interested in this.

Until we can get coordination of both research and planning—and the budget—we will go off in all directions like that gentleman aboard ship. So let me yield to Senator Gore here, we will hear other opening statements, and start with our witnesses. Senator Gore.

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OPENING STATEMENT BY SENATOR GORE

Senator GORE. Thank you very much, Mr. Chairman. Let me just begin by saying those of us who have been involved in this issue deeply appreciate your leadership, and the enormous amount of work that you have done on S. 169.

As you just indicated, one of the most important lessons we have learned is that more research and better research and better targeted research is absolutely essential, if we are going to eliminate the remaining areas of uncertainty and build the broader and stronger political consensus necessary for the unprecedented actions required to address this problem.

And as you have indicated as well, we need to act, and we need to act intelligently. There are many steps which should be taken for other reasons anyway. Dr. Bernthal, you have spoken recently about the findings of the Arctic team, which found the chemically destructive processes in place there that have already caused the ozone hole over the Antarctic.

There are at least two reasons why we should move to ban chlorofluorocarbons right away, in my opinion. I am looking forward to joining you and Bill Reilly as part of the delegation in London a few weeks from now. I also hope that in the follow-up meeting in Finland in April we can get a change in the Montreal protocol to move much more rapidly toward the elimination of these chlorofluorocarbons.

Other aspects of this problem also need attention. We should be halting deforestation for other reasons anyway, and the burning of the Amazon and other tropical areas are contributing enormous amounts of CO_2 to the upper atmosphere. Of course, we need to take the other steps as well.

On the opening day of this 101st Congress I introduced S. 201 to help address this challenge. The bill was carefully designed to complement the Chairman's bill, S. 169, which I was proud to cosponsor. I was also proud to have him as a cosponsor on S. 201. Other senators, including Senator Tim Wirth, have also introduced complementary legislation to address other parts of the problem.

I want to say, Mr. Chairman, that our subcommittee is going to be working very hard in this Congress to build more and more evidence in support of your legislation. Of course, the scientific community is already strongly behind it.

Tomorrow our subcommittee is going to have hearings on the ozone depletion problem and the role CFCs are playing, not only in destroying the ozone but also in contributing 15 to 20 percent of the global warming problem. We're going to look at a lot of the options tomorrow.

International cooperation is going to be essential if we're going to solve this problem. Success will rely on our ability not only to protect the atmosphere above our own homes but on our ability to work with our global neighbors. The United States is responsible for a major portion of the global warming and ozone depletion problems, but other nations also are responsible and we have to work with them to address the solutions that are available.

The situation is not at all as I remember it over on the House side when we had the first hearings on this eight years ago. At

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that time a lot of people shook their heads and said this is just a way out fringe issue. But we have learned since then, unfortunately, that it is all too real.

I want to close by again commending our chairman for bringing us together, for getting our committee right out in front and moving fastest and furthest. We are doing what the public rightly demands that we do to organize and focus the research. We will also begin those actions now which should take place for other reasons anyway, and to move forward expeditiously.

The 101st Congress is going to see us move in a bipartisan way and I appreciate your leadership, Mr. Chairman.

The CHAIRMAN. Thank you. Senator Kasten.

OPENING STATEMENT BY SENATOR KASTEN

Senator KASTEN. Mr. Chairman, thank you very much.

First of all, I would like to commend you, Mr. Chairman, and I would like to ask unanimous consent to be named as a co-sponsor of your legislation.

The CHAIRMAN. That will be included.

Senator KASTEN. I would like to focus on today, above all else, the point Senator Gore has just made—the fact that this is an international problem. The United States cannot solve it alone. We have got to lead the world in a cooperative effort to reduce the emission of greenhouse gases. I do not think we can be silent about projects that will touch off massive deforestations and thus have a devastating effect on the global climate.

Some countries might well decide when examining their development lending policies to favor short-term economic benefits over the long-term and environmental health of this planet. Evidently this is what Japan has chosen to do in supporting an environmentally destructive road-building project in the Brazilian rain forest. This was reported in last Sunday's New York Times.

Japan's Overseas Economic Development Corporation is planning to finance the destruction of a wide swath of Amazon rain forest. The project which the Japanese are considering has been turned down by the World Bank. It has been turned down by the Inter-American Development Bank. Even these institutions have come to realize the tremendous environmental cost of this project.

I am introducing a resolution today which expresses the Senate's displeasure with the Japanese proposal and calls on the Japanese to stop this project, and I am hopeful that we are going to be able to develop strong bipartisan support.

In addition, I am going to be asking for a meeting with the Japanese ambassador to discuss a reasonable approach to promoting development of this type. We are not against development, but what we must be against is the destruction of basic environmental resources. When it comes to the environment, especially the greenhouse effect, national borders are irrelevant.

Mr. Chairman, members of the committee, I'd like to thank you for holding this hearing on what I believe is the most important problem facing the world today.

Global climate change is a clear and presont danger. While it make take 20 years for increased carbon dioxide to increase our

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temperature, these changes are occurring right now—and their impact is cumulative. More and more greenhouse gases in the atmosphere cause an ever-increasing spiral of rising temperatures.

Senator Hollings deserves our support and our praise for the work he's done in crafting and advancing S. 169. I'd like to take this opportunity to join him as cosponsor of this legislation.

What I want to focus on today, above all else, is the fact that this is an international problem. The United States cannot solve it alone. We must lead the world in a cooperative effort to reduce the emission of greenhouse gases.

For example, I believe we cannot be silent about projects that will touch off massive deforestation and thus have a devastating effect on the global climate.

The most rapid growth in the emission of greenhouse gases is not in the industrialized world, but in developing nations. I understand that approximately 20 percent of the carbon loading in the atmosphere might be traced to the needless buring of tropical rain forests.

Some countries might well decide, when examining their development leading policies, to favor short-term economic benefits over the long-term environmental health of the planet. This, evidently, is what Japan has chosen to do in potentially supporting an environmentally destructive road-building project in the Brazilian rainforest.

As reported in last Sunday's New York Times, Japan's Overseas Economic Development Corporation's planning to finance the destruction of a wide swath of Amazon rainforest.

This road project is a continuation of the notorious BR-364 project. Two sections of this road previously financed by the World Bank and Inter-American Development Bank touched off unprecedented deforestation and related environmental devastation. An area almost twice the size of my home state of Wisconsin has now been deforested because of this road.

The project the Japanese are considering has been declined by the World Bank and by the Inter-American Development Bank. Even these institutions have come to realize the tremendous environmental costs of this project.

I am introducing a resolution today which expresses the Senate's displeasure with the Japanese proposal, and calls on the Japanese to stop the project until sufficient environmental protection is assured. I ask the support of all present for this resolution.

In addition, I will be asking for a meeting with the Japanese Ambassador to discuss a reasonable approach to promoting development of this type. We are not against development; what we must be against is the destruction of basic environmental resources.

I want to point out that I support development, in Brazil and elsewhere. I believe, however, that we cannot ignore environmental restraints on development.

When it comes to the environment, and especially the greenhouse effect, national borders are irrelevant. We shall all swim together, or sink beneath a deadly blanket of greenhouse gas—us, Japan, everybody.

We can't allow the Japanese or anyone else to ignore this vital truth.

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I believe that we can convince our Japanese friends to stand with us—provided we in Washington remain united.

For the past 6 years the Foreign Operations Subcommittee of our Appropriations Committee has waged a truly international struggle for the environment. We've worked for radical changes in both our own foreign assistance programs and those of multilateral institutions—to make sure these programs don't promote harmful changes in the global climate.

We have begun to institute extensive changes in institutions such as the World Bank and the Inter-American Development Bank to promote the conservation of forest resources instead of the clearcutting of millions of acres.

I believe we ought to go further, and make our effort even more international. Senator Hollings is taking an important step forward with this legislation. I would ask my colleague, Senator Hollings, to consider the State Department an important ally in his effort to accomplish the objective contained in S. 169.

The State Department coordinates U.S. policies with other nations. International cooperation is crucial to the development of an effective program of combatting global climate change. To address this problem, we have to put in place an international protocol or treaty governing the production and emission of greenhouse gases. The State Department is the only department equipped to serve as a lead agency in promoting such a protocol.

A model protocol has already been enacted to control CFC's (chlorofluorocarbons). The Montreal Protocol is an important first step in controlling this critical ozone-depleting greenhouse gas. But it is not enough. We should make a commitment now to pursue a similar treaty on all greenhouse gases.

The store of scientific knowledge which Senator Hollings' legislation will create is critical to our understanding of the greenhouse effect. We need that information if we want to continue our fight into the next century.

For today, though, we know enough to begin our work. The information we have points to one conclusion: We must cooperate with great urgency to make the battle against the greenhouse effect an international fight. With the leadership of this committee and others, we can achieve a treaty—and win our battle for the biosphere.

The CHAIRMAN. Senator Exon.

OPENING STATEMENT BY SENATOR EXON

Senator EXON. Mr. Chairman, thank you very much, and I want to add my voice and compliment you as chairman of the committee and Senator Gore as the chairman of the subcommittee of jurisdiction, for starting these hearings. We obviously have to do something, and the 101st Congress, I think, is in line for several very important decisions. None, in my opinion, is more important to the future of mankind than what we are discussing here today.

I do hope, and I would echo the chairman's statements about the proliferation of efforts throughout the various committees. If we start that, everybody will want to get in on the act because it is the in thing to do now. This is far too important for us to argue over

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whose jurisdiction it is. We have got to get together in a true bipartisan way and work at the problem.

Those of us who are not scientists continue to be amazed at what is going on with our environment today. I have been in Phoenix, Arizona and Los Angeles, California, and Denver, Colorado, within the last three months, and all you have to do is look about those cities and see that we have a serious pollution problem.

I do not begin, as a layman, to understand all the intricacies of the greenhouse effect, but I am very, very much concerned about it. As one who has pushed a strong environmental agenda for a long, long time I am glad to see we are moving in this area.

I would simply point out that Nebraska took the lead in this matter with the development of what we call gasohol way back when I was governor. Now I see that many states and cities including Denver, Colorado and Phoenix, Arizona, have taken action to mandate that ethanol be used for up to 10 to 15 percent of the mixture in all gasoline that is sold as a means of reducing auto emissions.

I hope we do not have to take federal action on this, but indeed we might have to. I would like to have your statements as expert witnesses as to whether such actions begin to take at least a tiny first step in addressing the problem.

Second, I would hope that today sometime, and I have not had a chance to read all of your written testimony, that you could advise us regarding a split in the scientific community as to whether or not the problem facing us as a world is indeed a warming trend. As I understand it, some very respected scientists maintain we are going the other way, and we are getting colder rather than warmer.

We want to listen to all sides on this, and I am particularly concerned as a layman about those warnings that I have heard. Although the greenhouse effect may be a problem, consider the opposite, which is a cooling trend in the world. As we wrestle with these issues, I hope you can help us straighten them out because I think it is very important.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you. Senator Bryan.

OPENING STATEMENT BY SENATOR BRYAN

Senator BRYAN. Thank you, Mr. Chairman. I too want to join with the rest of our colleagues here in complementing you on your leadership in bringing this issue to the fore so early in the session.

I am pleased to be a cosponsor on S. 169. In my view, the timing is extraordinarily propitious. Whether there is a direct correlation between the greenhouse effect or the long-term warming trend that some have argued is existing, clearly last summer's protracted heat wave and the drought seared in the public consciousness that weather, and climate, and global change can have a profound impact on the way in which we live and can affect us.

I think in that sense there is a real opportunity that we have on this committee, because the public's attention has been captured. It goes beyond those who are technically well-versed in this. It now, to use Senator Exon's statement, affects all of the public and lay

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people as well who have an interest and a concern. I think we really have an opportunity to make a difference in this Congress and I look forward to working with you, Mr. Chairman, and the rest of the committee.

The CHAIRMAN. Thank you. Senator Packwood.

OPENING STATEMENT BY SENATOR PACKWOOD

Senator PACKWOOD. Thank you, Mr. Chairman. First, could I ask unanimous consent that you place me on the bill as a co-sponsor?

The CHAIRMAN. You will be included.

Senator PACKWOOD. Secondly, I remember in 1975, when I introduced a bill to ban fluorocarbons in aerosol cans and it passed two years later, and we thought, that takes care of the problem; we know we have licked it. And now, that was nothing but a speck of sand on the beach in terms of what the problem is now.

We have now an opportunity, although it is going to involve leadership and cooperation rather than coercion. We have an opportunity to start down the road to making a difference in the world. But when I say cooperation, there is nothing we can do to coerce Brazil into saving their forest. There is a limit to our powers, whether we proved that in Vietnam or otherwise.

We are going to have to take the lead in convincing the world for their own good, not just our good, for their own good, that they understand the evidence, which is now overwhelming, and that they take the steps necessary for their own salvation Mr. Chairman, in the long run that may be a harder job than winning a military war, to convince people to undertake steps that in the short-run they think may limit their economic opportunities for the sake of their long-run salvation.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you. Senator Kerry.

OPENING STATEMENT BY SENATOR KERRY

Senator KERRY. Thank you, Mr. Chairman, very much. I would like to ask unanimous consent that my opening comments be placed in the record.

I would just like to join with my colleagues in applauding you for holding this hearing, and I want to thank you for the leadership that you provided through the National Ocean Policy Subcommittee which I have had the privilege to vice-chair.

I think perhaps one of the most important aspects of the legislation that you have introduced, which I am pleased to co-sponsor, is the fact that despite the extraordinary talents that we have within the various agencies that are engaged in research, we really do not have an overall strategy or a plan now. There is an unfortunate degree of competition, turf struggle, and jurisdictional tension, when there ought to be a unanimous all-fronts cooperative effort.

And it is my hope that this hearing process, as well as the legislation, will see us assume the proper role of research leadership and strategic leadership that we ought to be exercising in this area.

I note with pleasure that Secretary Baker in his opening comments on January 30 before the Intergovernmental Panel on Climate Change stressed that, notwithstanding some of the uncertain-

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ties of the scientific evidence, he felt it was vital that we take certain actions now.

So I welcome these hearings and the hearing tomorrow which Senator Gore will chair, in an effort to try to really put the 101st Congress on record as clearly determined to try to move in this arena. We will try to assist Dr. Bernthal and others to make certain that we cease whatever agency prerogatives some individuals may feel are being stepped on and set some priorities, because it is vital for all of us that we do so.

I want to thank the Chairman for holding today's very important hearing. As a cosponsor of his legislation S. 169, the National Global Change Research Act, let me just say that we both agree that there is much to be accomplished and coordinated in the area of global change.

The problems associated with global warming and the magnitude of what needs to be done causes me great concern. Through population growth, modern industrialization and energy use, mankind is clearly changing its global environment. Issues must be addressed such as: what are the future consequences of global warming on the world environment? And what can we do to stop this dangerous trend?

It is clear that our global environment is being attacked from all sides. Today the ozone layer is deteriorating over Antarctica, the tropical forests of the world are being burned and cut to extinction, the emission of carbon dioxide from fossil fuels threaten our climatic system—a system that has nurtured the natural world on which we all depend. Manmade greenhouse gases are being emitted into the air at an increasingly disturbing rate thus, trapping heat in the atmosphere causing a warming trend on earth. And on another front, acid rain is assaulting our health by polluting the air that we breath, not to mention the devastation it is causing to our rivers, lakes, streams and marine life in our oceans. Plastic pollution is dominating our waste stream, strangling our marine habitats and overburdening the capacity to landfill. All of these concerns are problems that span across our Congressional Committee system, go well beyond any federal agency, and transcend all national boundaries. That is why the task before Congress—and a very difficult one it is—is to begin to aggressively and more comprehensively address worldwide, or at least transnational, environmental problems.

Today's hearing focuses on one of the major environmental concerns facing us today—global warming. Scientists differ in their perceptions as to the magnitude of the problem of the so called greenhouse effect. It is uncertain when global warming from the greenhouse effect will actually occur, it is unclear to what degree food production will be altered or how high our oceans will rise, or what sort of increase we can expect with regard to severe weather patterns. But despite these uncertainties regarding the extent of and the specific nature of its consequences, there is an overwhelming consensus throughout the scientific and environmental community that a greenhouse warming is taking place and the results will cause profound damage to our global habitat. Now is the time for action while we may still have some time on our side. Now is the

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time to address the issue, not later when it is too late and the problems are insurmountable.

The legislation that our Chairman introduced at the beginning of this session of Congress sets off on the right track. The bill mandates a federal research plan to study global environmental change, including greenhouse warming and ozone depletion. The need for such coordination has become increasingly evident because there appears to be a lack of coordination between federal agencies as well as, with private researchers. To that end, the chairman's legislation, which I am pleased to cosponsor, provides for improved planning and coordination of interagency research programs.

Although the United States has made significant environmental improvements, particularly in the air that we breath, over the past two decades, we still emit roughly 15 percent of the world's sulfur dioxide, 25 percent of all nitrogen oxide, over 25 percent of the carbon dioxide and still produce approximately 30 percent of all Chlorofluorocarbons (CFC's). All of these pollutants can be significantly reduced and CFC's should be completely phased out by the year 2000.

Therefore, the new Administration and its agencies can hold the key in making a responsible difference. With regard to the direction in which the President plans to point his Cabinet Secretaries—the jury is still out. However, I was heartened by the comments of our new Secretary of State James Baker on January 30th when he opened the meeting of the 17 nation working group known as the Intergovernmental Panel on Climatic Change. His comments indicated a new and more activist approach than what we had been use to from the previous Administration. He called for action not merely study. The Secretary was clear and persuasive in his statement that we cannot wait until all of the scientific evidence is in before we begin to take action on addressing the problems associated with the greenhouse effect. I appreciate that direction. As one who has actively pursued putting an end to acid rain pollution, and found the past eight years dominated by one study after another instead of real action, I plan to watch closely and assist in any way possible to ensure that the greenhouse effect does not fall pray to arguments of study only, versus real action.

Throughout the agency structure there is so much that can be done. The State Department can deal with this issue on a myriad of fronts. Through the IMF, the World Bank and other multilateral development banks the United States has influence on decisions that effect the environment, particularly in sustainable development and biological diversity. AID reauthorization and debt for nature swaps are also areas where the Secretary of State may begin to look.

Last year I was joined by 70 of my colleagues in calling for a high-level international summit on global environmental problems. Now more than ever, I believe that the State Department needs to push that idea. The Secretary of Commerce has an opportunity to play an active role in curbing CO_2 emissions. By strengthening the fuel efficiency standards we could cut by one-third the amount of CO_2 in the atmosphere. The Secretary through NOAA has the best climate research and monitoring mechanism in place, not to men-

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tion NOAA's ability to add to the debate on how global warming and our oceans interact. NSF, NASA, and NOAA, if given the proper direction and resources can answer so many of the unresolved questions, and can do so in a coordinated, cost effective way. The Secretary of Energy can embark on new alternative energy sources and conservation programs thus moving us away from the endless burning of fossil fuels. And the Administrator of EPA through its regulatory process can play a key role in source reduction of pollutants thus curbing many of the pollutants that lead to the greenhouse effect. Given the appropriate direction, these agencies can play a significant role in informing and shaping the debate and policy response to global warming, and that is why the Hollings bill is so key.

Mr. Chairman, global warming is a world wide environmental challenge. The United States cannot solve the problems unilaterally, but we can certainly lead the way. I look forward to hearing the thoughts and ideas of our distinguished witnesses today on this critical issue.

Finally, I would simply say that notwithstanding uncertainties within the scientific community as to the various models and what they say as to where, or when, or how, areas may be most impacted by the warming, there is I think a virtual consensus that the warming is taking place, that we are contributing to it, and that it will have an overall damaging impact.

Now if we cannot summon the political will and leadership to respond to that, then we are obviously seriously handicapped. So Mr. Chairman, I thank you for having this hearing and look forward to working with you.

The CHAIRMAN. Very good. Senator McCain.

Senator MCCAIN. Thank you, Mr. Chairman. I am pleased to be a co-sponsor of this legislation, and I think its time has come, and I hope we will be able to move this legislation as rapidly as possible and I thank you for your leadership on this issue.

The CHAIRMAN. Thank you. Senator Bentsen.

Senator BENTSEN. Mr. Chairman, I want to get on with hearing these distinguished witnesses. I thank you for calling the hearing and I am delighted to be a co-sponsor.

The CHAIRMAN. Senator Stevens.

Senator STEVENS. Mr. Chairman, I too am pleased to be here. I think I am a co-sponsor. If I am not, I wish to be.

The CHAIRMAN. You are.

Senator STEVENS. I believe in this, and I thank you for having the hearings.

The CHAIRMAN. Senator Gorton.

Senator GORTON. I would simply say, I too commend you Mr. Chairman, and I am happy to be a co-sponsor of this legislation and look forward to hearing from our distinguished panel of witnesses.

The CHAIRMAN. All right. I have been fully commended. Thank you all very much.

[The bill follows:]

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101ST CONGRESS
1ST SESSION

S. 169

To amend the National Science and Technology Policy, Organization, and Priorities Act of 1976 in order to provide for improved coordination of national scientific research efforts and to provide for a national plan to improve scientific understanding of the Earth system and the effect of changes in that system on climate and human well-being.

IN THE SENATE OF THE UNITED STATES

JANUARY 25 (legislative day, JANUARY 3), 1989

Mr. HOLLINGS (for himself, Mr. KERRY, Mr. GORE, Mr. DANFORTH, Mr. INOUYE, Mr. BUMPERS, Mr. RIEGLE, Mr. PRESSLER, Mr. WILSON, Mr. MCCAIN, Mr. CRANSTON, Mr. BENTSEN, Mr. BRYAN, Mr. WIRTH, and Mrs. KASSEBAUM) introduced the following bill; which was read twice and referred to the Committee on Commerce, Science, and Transportation

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A BILL

To amend the National Science and Technology Policy, Organization, and Priorities Act of 1976 in order to provide for improved coordination of national scientific research efforts and to provide for a national plan to improve scientific understanding of the Earth system and the effect of changes in that system on climate and human well-being.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

That this Act may be cited as the "National Global Change Research Act of 1989".

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SEC. 2. Section 102(a)(6) of the National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6602(a)(6)) is amended to read as follows:

"(6) The development and implementation of long-range, interagency research plans to support policy decisions regarding identified national and international concerns, and for which a sustained and coordinated commitment to improving scientific understanding will be required.".

SEC. 3. (a) Section 401 of the National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6651) is amended to read as follows:

"FUNCTIONS OF COUNCIL

"SEC. 401. (a) The Federal Coordinating Council for Science, Engineering, and Technology (hereinafter referred to as the 'Council') shall consider problems and developments in the fields of science, engineering, and technology and related activities affecting more than one Federal agency, and shall recommend policies and other measures designed to—

"(1) provide more effective planning and administration of Federal scientific, engineering, and technological programs;

"(2) identify research needs, including areas requiring additional emphasis;

"(3) achieve more effective utilization of the scientific, engineering, and technological resources and fa-

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cilities of Federal agencies, including the elimination of unwarranted duplication; and

"(4) further international cooperation in science, engineering, and technology.

"(b) The Council may be assigned responsibility for developing long-range and coordinated plans for scientific and technical research which involve the participation of more than two Federal agencies. Such plans shall—

"(1) identify research approaches and priorities which most effectively advance scientific understanding and provide a basis for policy decisions;

"(2) provide for effective cooperation and coordination of research among Federal agencies; and

"(3) encourage domestic and, as appropriate, international cooperation among government, industry, and university scientists.

"(c) The Council shall perform such other related advisory duties as shall be assigned by the President or by the Chairman of the Council.

"(d) For the purpose of carrying out the provisions of this section, each Federal agency represented on the Council shall furnish necessary assistance to the Council. Such assistance may include—

"(1) detailing employees to the Council to perform such functions, consistent with the purposes of this sec-

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tion, as the Chairman of the Council may assign to them; and

"(2) undertaking, upon request of the Chairman, such special studies for the Council as come within the scope of authority of the Council.

"(e) For the purpose of developing interagency plans, conducting studies, and making reports as directed by the Chairman, standing committees, and working groups of the Council may be established.".

(b) Section 207(a)(1) of the National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6616(a)(1)) is amended by striking "established under title IV".

SEC. 4. The National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6601 et seq.) is amended by adding at the end thereof the following new title:

"FINDINGS AND PURPOSE

"SEC. 601. (a) Congress finds and declares the following:

"(1) Industrial, agricultural, and other human activities, coupled with an expanding world population, are contributing to processes of global change that may significantly alter our habitat within a few human generations.

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"(2) Such human-induced changes may lead to significant global warming and the depletion of stratospheric ozone, and thus have the potential to alter world climate patterns, increase global sea levels, and reduce the ability of the atmosphere to screen out harmful ultraviolet radiation. Over the next century, the consequences could seriously and adversely affect world agricultural and marine production, coastal habitability, regional economic well-being, human health, and biological diversity.

"(3) Development of effective policies to mitigate and cope with human-induced global changes will rely on greatly improved scientific understanding of global environmental processes and on our ability to distinguish between the effects of human activities on one hand and the results of natural change on the other.

"(4) New developments in interdisciplinary Earth sciences, global observing systems, and computing technology make possible significant advances in the scientific understanding and prediction of these global changes and their effects.

"(5) Efforts are ongoing in several Federal agencies which could contribute to a well-defined and coordinated national program of research, monitoring, assessment, information management, and prediction.

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"(6) The United States, as a world leader in Earth system science, should continue to provide leadership in developing and implementing an international global change research program.

"(b) It is the purpose of Congress in this title to provide for a national global change research plan which when implemented will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change.

"NATIONAL GLOBAL CHANGE RESEARCH PLAN

"SEC. 602. (a)(1) The President, through the Council, shall develop a National Global Change Research Plan (hereafter in this title referred to as the 'Plan') in accordance with section 401(b) of this Act and the provisions, findings, and purpose of this title. Consistent with the responsibilities set forth under subsection (d) of this section, the Plan shall contain recommendations for a ten-year national research effort, to be submitted to Congress within one year after the date of enactment of this title and to be revised at least once every three years thereafter.

"(2) The Plan shall—

"(A) establish the goals and priorities for Federal global change research for the ten-year period beginning in the year the Plan (or revised Plan) is submitted;

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"(B) set forth the role of each Federal agency and department in implementing the Plan;

"(C) describe the levels of Federal funding and specific activities, including research activities, data collection and analysis requirements, predictive modeling, participation in international research efforts, and information management, required to achieve such goals and priorities; and

"(D) consider and utilize, as appropriate, reports and studies conducted by Federal agencies and departments, the National Research Council, or other entities.

"(3) The Plan shall address, where appropriate, the relevant programs and activities of the following Federal agencies and departments—

"(A) the Department of Commerce, particularly the National Oceanic and Atmospheric Administration;

"(B) the National Science Foundation;

"(C) the National Aeronautics and Space Administration;

"(D) the Department of the Interior, particularly the United States Geological Survey;

"(E) the Department of Energy;

"(F) the Department of Agriculture;

"(G) the Environmental Protection Agency;

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"(H) the Department of Defense, particularly the Department of the Navy; and

"(I) such other research agencies and departments as the President, or the Chairman of the Council, considers appropriate.

"(b) The Council shall—

"(1) serve as lead entity responsible for oversight of the implementation of the Plan;

"(2) coordinate the global change research activities of Federal agencies and departments and report at least annually to the President, through the Chairman of the Council, on any recommended changes in agency or departmental roles that are needed to better implement the Plan;

"(3) prior to the President's submission to Congress of the annual budget estimate, review each agency budget estimate in the context of the Plan and make the results of that review available to each agency and to the appropriate elements of the Executive Office of the President, particularly the Office of Management and Budget;

"(4) work with Federal agencies, with the National Research Council, and with academic, State, and other groups conducting research and assessments of global changes and their effects;

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"(5) coordinate Federal interagency participation in international activities related to global change research and assessment; and

"(6) consult with actual and potential users of such research and assessments.

"(c) The Plan shall provide for, but not be limited to, the following research elements:

"(1) Global measurements, establishing worldwide observations necessary to understand the physical, chemical, and biological processes responsible for changes in the Earth system on all timescales.

"(2) Documentation of global change, including the development of mechanisms for recording changes that will actually occur in the Earth system over the coming decades.

"(3) Studies of earlier changes in the Earth system, using evidence from the geological and fossil record.

"(4) Predictions, using quantitative models of the Earth system to identify and simulate global trends.

"(5) Development of an information base, the assembly of the information essential for effective decisionmaking to respond to the consequences of global change.

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"(6) Basic research directed toward improving scientific understanding of specific aspects of the Earth system.

"(d)(1) The Plan shall take into consideration, but not be limited to, the following existing agency missions and responsibilities—

"(A) The National Science Foundation shall continue to be responsible for basic research in all areas of Earth, atomspheric, and ocean science, including the relevant biological sciences. Such basic research may include ground-based measurements for regional and global studies; polar studies; large-scale field programs; interpretation and use of space-based data; theoretical and laboratory studies; research facilities support; and development of numerical models, information and communication systems, and data bases.

"(B) The National Aeronautics and Space Administration shall have primary responsibility for Earth science research missions from space, including those of broad scientific scope, to study the Earth as an integrated whole. Associated efforts may include related ground studies; remote-sensing and advanced instrument development; and improvement of techniques for the transmissions, processing, archiving, retrieval, and

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use of data and related models; and other research activities.

"(C) The National Oceanic and Atmospheric Administration shall continue to be responsible for operational environmental satellite programs and research programs on ocean and atmospheric processes. Additional responsibilities shall include climate diagnostics and prediction; development of predictive models and techniques for detecting natural and human-made changes; acquisition, maintenance, and distribution of long-term data bases; calibration and validation of environmental observations; processing and archiving of space-based and ground-based data; and development and support of ground-based oceanic and atmospheric monitoring systems.

"(D) The United States Geological Survey shall have primary responsibility for geological studies and mapping. Additional areas of responsibility shall include paleoclimate, hydrologic cycles, geographical information systems, and management of land remote-sensing data, including acquisition, maintenance and distribution of long-term data bases for these areas.

"(E) The Environmental Protection Agency shall have primary responsibility for research to assess and evaluate the ecological and environmental conse-

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quences of global change, including the interaction of plant and animal communities and ecosystems. Additional areas of responsibility shall include evaluations of the impact of global atmospheric change on regional air and water quality, development of emission factors, and inventories for important trace gases other than carbon dioxide.

"(F) The Department of Energy shall have primary responsibility for research on atmospheric carbon dioxide emission measurement and research to establish a comprehensive national energy policy for reducing carbon dioxide and other trace gas emissions. Associated efforts may include assessment and application of predictive models, evaluation of the climatic effects of various energy policy options, and research on industrial sources of trace gases.

"(2) The Plan shall reflect the need for collaboration among agencies with respect to—

"(A) the establishment and development of an information system for Earth system science; and

"(B) basic research into the development of new conceptual and numerical models of the Earth system.

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"(e) The Chairman of the Council and the Secretary of State shall cooperate in—

"(1) providing representation at international governmental meetings and conferences on global change in which the United States participates; and

"(2) coordinating the Federal activities of the United States with the global change research and assessment programs of other nations and international agencies and organizations, including the World Meteorological Organization and the United Nations Environmental Program.

"(f) Each Federal agency and department involved in global change research shall, as part of its annual request for appropriations to the Office of Management and Budget, submit a report identifying each element of its proposed global change activities, which—

"(1) specifies whether each such element (A) contributes primarily to the implementation of the Plan or (B) contributes primarily to the achievement of other objectives but aids Plan implementation in important ways; and

"(2) states the portion of its request for appropriations that is allocated to each such element.

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The Office of Management and Budget shall review each such report in light of the goals, priorities, and agency responsibilities set forth in the Plan, and shall include, in the President's annual budget estimate, a statement of the portion of each agency or department's annual budget estimate that is allocated to each elment of such agency or department's global change activities. The Office of Management and Budget shall ensure that a copy of the President's annual budget estimate is transmitted to the Chairman of the Council at the same time as such budget estimate is submitted to Congress.

"RELATION TO OTHER LAWS

"SEC. 603. (a) The President, the Chairman of the Council, and the Secretary of Commerce shall ensure that relevant research activities of the National Climate Program, established by the Natioual Climate Program Act (15 U.S.C. 2901 et seq.), are considered in developing national global change research efforts.

"(b) The President, the Chairman of the Council, and the heads of the agencies represented on the Council shall ensure that the research findings of the Council and of Federal agencies and departments are available to the Environmental Protection Agency for use in the formulation of a coordinated national policy on global climate change pursuant to section 1103 of the Global Climate Protection Act of 1987 (15 U.S.C. 2901, note).

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"ANNUAL REPORT

"SEC. 604. The Chairman of the Council shall prepare and submit to the President and Congress, not later than January 31 of each year, an annual report on the activities conducted pursuant to this title during the preceding fiscal year, including—

"(1) a summary of the achievements of Federal global change research efforts during that preceding fiscal year;

"(2) an analysis of the progress made toward achieving the goals and objectives of the Plan;

"(3) a copy or summary of the Plan and any changes made in such Plan;

"(4) a summary of agency budgets for global change activities for that preceding fiscal year; and

"(5) any recommendations regarding additional action or legislation which may be required to assist in achieving the purposes of this title.".

O

The CHAIRMAN. The committee is delighted this morning to have Frederick Bernthal, who is the Assistant Secretary for Oceans and International Environmental and Scientific Affairs at the Department of State, and our old friend, Dr. Robert Corell, who is the Assistant Director for Geosciences at the National Science Foundation. We welcome you both, and we are glad to hear from you, Secretary Bernthal, at this time.

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STATEMENT OF FREDERICK M. BERNTHAL, ASSISTANT SECRETARY FOR OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS, DEPARTMENT OF STATE

Mr. BERNTHAL. Thank you, Mr. Chairman. I would like first to request the permission of the chair to insert the full text of my remarks into the record.

The CHAIRMAN. It will be included, and you can highlight it or give it in full, as you wish.

Mr. BERNTHAL. I propose to paraphrase and highlight that statement and emphasize a few points that I think need to be made.

It may have been for the wrong reason, but never mind the reason. It was high time that this issue come before the American consciousness, and the wrong reason may have been the drought in the Great Plains.

Whatever it may have been, the global climate change issue has suddenly become the most important environmental issue of the day and may well become the dominant foreign policy issue of the 21st century.

This issue will place our political leaders in the unenviable position of having to distinguish between a problem that is serious and one that is a crisis. Making that distinction will not be easy, but we should be prepared to respond to what is now a serious issue before it becomes a full-blown crisis.

President Bush has said, "Those who think we are powerless to do anything about the greenhouse effect are forgetting about the White House effect. And, as President, I intend to do something about it."

The scientific community, as some have noted here already, is cautious about what it is willing to say on the specifics of future climate change. The magnitude, the timing, and the regional climatic effects are far from certain. But, even a decision to do nothing today will have profound implications.

Moreover, it is never easy to maintain political interest in an issue that promises to span the careers and indeed the lifetimes of everyone sitting in this room today. But, there has to be political focus and continuity on this issue, Mr. Chairman, despite the short-term drought. We hope it is short-term drought in the Great Plains, despite the New York Times telling us that the hundred year record of the evidence shows no evidence after all for warming in the U.S., and despite some future decade of cooling that might cause the warmth of the 1980s to fade in our collective memory, because none of these changes will alter the fundamental facts.

Greenhouse gases are accumulating in the atmosphere of our planet, and one thing is clear. Other things being equal, simple physics says the world should get warmer.

It is also clear that global warming is inherently an international problem, one that transcends national boundaries, one that can find no resolution without global participation. As environmental issues go, this one breaks the mold.

Now, Mr. Chairman, as I think everyone here knows by now, an international process to address this problem is now underway. The United Nations Environment Program and the World Meteorologi-

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cal Organization last year jointly established an ad hoc intergovernmental mechanism to consider global climate change and the policy implications of that change.

In fact, on election week last fall representatives of over 35 nations and international organizations met in Geneva to organize the Intergovernmental Panel on Climate Change, the IPCC, as it has come to be called.

The U.S. strongly supported establishment of this IPCC as the principal international forum for addressing this issue and, in fact, the delegation which I led included representatives from EPA, the Departments of Energy, Commerce, Interior, White House Office of Science and Technology Policy, National Science Foundation, the Congress, and other agencies.

The IPCC established three working groups last November: One to review and assess the state of the science, a second to assess the possible environmental and socioeconomic impacts of global warming, and a third to identify potential response strategies.

The United Kingdom chairs the science working group, the U.S.S.R. the impacts working group, and the United States has taken on the response strategies working group—as you can imagine, the most political of those three groups.

Pursuant to that meeting, the U.S.-chaired response strategies working group first convened at the Department of State January 30th to February 1st of this year with representatives of 32 nations. A broad range of international and nongovernmental organizations were in attendance; it was one of the largest international meetings hosted by the department in the last 15 years.

That meeting set goals for analysis of both short and long-term policy options. Four topical subgroups were established: Energy and Industry, chaired by Japan and either Canada or China, still to be resolved; Agriculture, Forestry and Other Human Activities, chaired by the Federal Republic of Germany and Zimbabwe; the third subgroup on Coastal Zone Management, chaired by New Zealand and the Netherlands; and the fourth group on Resource Use and Management, chaired by France and India and either Canada or China.

The first two of these subgroups, the energy and industry and the agriculture-forestry subgroups, will consider strategies for limiting the rate of climate change, and the second two, coastal zone management and resource use and management, as you can pretty well tell by the titles, will consider strategies for adapting to climate change should it occur.

The efforts of this response strategies working group will be coordinated by a steering committee to ensure that priority paths are carried out.

What does that mean? For example, working group one, the science working group, has already asked for an early reporting of greenhouse gas emissions scenarios to form the basis for climate modeling. The scenarios to be explored include those for an effective doubling, an effective doubling of atmospheric CO_2 by the years 2030, 2060, and 2090, we believe an appropriate spread in time.

That kind of hundred year perspective, Mr. Chairman, is needed so that we can try to determine what our climate future holds,

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whether that future is acceptable, and how it might be modified should that become necessary.

As chairman of working group three, the response strategies working group, I had the pleasure in this meeting earlier this year of introducing Secretary Baker for his first statement before an international forum.

The Secretary made four key points. First, we probably cannot afford to wait until all of the scientific uncertainties have been resolved before we do act. Time will not make the problem go away.

Second, while scientists refine the state of our knowledge, we should focus immediately on prudent steps, already justified on grounds other than climate change, things that we will never regret whether or not climate change ever occurs. These include reducing CFC emissions, greater energy efficiency and reforestation.

Third, whatever global solutions to global climate change are considered, they should be as specific and as cost-effective as they possibly can be.

And, finally, those solutions will be most effective if they transcend what the Secretary referred to as the great fault line of our times, the need to reconcile the human imperative for both economic development and a safe environment.

Mr. Chairman, that the U.S. must play a major role in understanding and resolving this problem is inescapable. Any significant change in global weather patterns will affect our climate and our socioeconomic structure, too. And, to the extent that there is a problem, we are a major contributor as the largest single consumer of energy and emitter of CO_2—in fact, about a quarter of all anthropogenic CO_2.

We have much of the scientific expertise necessary to understand the situation and the technology needed to respond if necessary.

In keeping with that theme, Mr. Chairman, I want to make a comment or two on S. 169, the bill which you have recently introduced, because in my judgment that represents an appropriate response by Congress to the issues of global change in general and of climate change in particular. It correctly emphasizes the need to develop and implement a long-range interagency research plan to address emerging global change issues.

I would emphasize that if the international cooperative scientific assessment of global climate change is to succeed, there must be timely and credible scientific response by the U.S. and S. 169 is an important step toward that end. The bill would support and lend coherence to the recent efforts of the Federal Coordinating Committee on Science, Engineering and Technology, the so-called FCCSET committee, to use the Committee on Earth Science, CES, to provide a focus for global change research.

I would note that the language of section 602(e) will be carefully reviewed by the administration to ensure its conformance with current law and agency responsibility in the conduct of international science and technology policy.

The Federal Coordinating Committee on Science, Engineering and Technology will, in fact, provide a focus for federal global change research, and Dr. Corell is going to explain that in more detail, so I will not go into that matter further now.

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In closing, Mr. Chairman, I would just note that need for research on global change has never been more evident. Professional scientific and policy journals are filled with articles and considerable speculation about the magnitude, timing, and possible effects of global change, especially climate change.

As S. 169 recognizes, one of our first tasks is to achieve a better scientific understanding of what is actually occurring and what the effects might be. At the same time, under the program set forth by the IPCC, we are already beginning to identify and examine options for responding to what may become the dominant environmental and indeed foreign policy issue of the 21st century.

Thank you very much, Mr. Chairman.

[The statement follows:]

STATEMENT OF FREDERICK M. BERNTHAL, ASSISTANT SECRETARY OF STATE, BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS

I am pleased to testify this morning on the greenhouse effect and global change. The greenhouse effect and global climate warming may well become a major foreign policy issue of the 21st century. But you, and we in the executive branch, are also concerned with other changes in the global environment that could alter human life within two or three generations—disturbing phenomena such as widespread deforestation and desertification, ocean pollution, the disappearance of coastal and terrestrial wetlands, and the depopulation of certain animal and avian species due to human industrial, agricultural, and fisheries activities.

S. 169 represents a timely response by Congress to the issues of broad global change and specific global climate change. It correctly emphasizes the need to develop and implement a long-range interagency research plan to support policy decisions on global change. Dr. Corell will present a statement of support for S. 169. I share the view that S. 169 represents an important step in recognizing and focusing the recent efforts of the Federal Coordinating Committee on Science, Engineering, and Technology (FCCSET) to coordinate Federal global change research through its Committee on Earth Sciences (CES). CES possesses both within itself and through its close contacts with scientific organizations a widespread expertise in both atmospheric and earth sciences.

For these reasons, we have asked the CES to directly assist U.S. participation in the IPCC science assessment. CES was established by the director of the Office of Science and Technology Policy in 1987 specifically to increase the overall effectiveness and productivity of Federal research and development efforts directed toward an understanding of the Earth as a global system. The CES mandate includes coordination of long range research into global climate change. The committee is currently developing a long-term research program pursuant to the strategy outlined in the CES report "Our Changing Planet" which accompanied the President's Fiscal year 1990 Budget Message. Moreover, CES is coordinating its activities with the International Council of Scientific Unions' International Geosphere/Biosphere Program which is exploring the origin and nature of global change.

The current FCCSET efforts deserve Congressional support such as is provided in S. 169. I would note that the language of section 602(e) will be carefully reviewed by the Administration to ensure its conformance with current law and agency responsibility in the conduct of international science and technology policy.

The need for long-term environmental research on global change, including global climate change, has never been greater. As we all know, the professional journals and the media have been filled with articles and speculations about the extent and pace of potentially disruptive global changes, especially climate change. We have been told that the "greenhouse effect" is already here and irreversible. We have also been told that the one hundred year record shows no evidence after all for warming in the U.S. And we have been told that, even if global warming should occur as a result of the greenhouse effect, Mother Nature may kick in self-adjusting mechanisms in the form of expanded cloud cover caused by increased evaporation that will automatically block out more sunlight, thus cooling the Earth. Clearly we need both more data and more thought about the effect of human behavior and natural phenomena on the environment of planet Earth.

The impact of climate warming and possibly some other global changes as well, such as deforestation and desertification, could be great. The challenge we face is

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that we soon may have to make decisions with far-reaching implications, even in the face of important uncertainties about critical aspects of the global change problem. Even a decision to do nothing has far-reaching implications. Moreover, it is never easy to maintain political interest in an issue that will span the careers—indeed the lifetimes—of everyone here today. But there must be political focus and continuity on the many problems of global change, and particularly global climate change. As President Bush has said, "those who think we're powerless to do anything about the 'greenhouse effect' are forgetting about the 'White House effect.' As President, I intend to do something about it."

It is clear that global warming is inherently an international problem. It is a problem that transcends national boundries and can find no resolution without global participation. Action by us alone would not be effective.

Recognizing that an international process was needed to address the greenhouse gas climate warming issue, the United States in the summer of 1987, urged the governing bodies of the World Meteorological Organization and the United Nations Environmental Program to establish jointly an intergovernmental mechanism to consider global climate change.

Last fall representatives of over 35 nations and international organizations met in Geneva for the first meeting of the Intergovernmental Panel on Climate Change (IPCC). The U.S. strongly supported establishment of the IPCC as the principal international forum for addressing this issue.

The delegation which I led included representatives from the EPA, the Departments of Energy, Interior and Commerce, the National Science Foundation, the Congress, and others.

The IPCC established three working groups: one to review and assess the science relevant to climate change, another to assess the possible environmental and socioeconomic impacts of such change, and a third to identify potential response strategies. The United Kingdom chairs the science assessment working group, the USSR the impacts working group, and the U.S. has taken on the response strategies working group.

Pursuant to that meeting, the U.S.-chaired response strategies working group [RSWG] first convened at the Department of State January 30–February 1, with representatives of 32 nations and a broad range of international and non-governmental organizations in attendance.

The meeting set goals for analysis of both short and long-term policy options. Four topical subgroups were established: Energy and Industry, chaired by Japan and (Canada or China); Agriculture, Forestry and other, chaired by the Federal Republic of Germany and Zimbabwe; Coastal Zone Management, chaired by New Zealand and the Netherlands; and Resource Use and Management, chaired by France and India and (Canada or China).

The first two sub-groups will consider strategies for limiting the rate of climate change; the second two for adapting to climate change.

The goals for the subgroups are to: Define policy options for national, regional and international actions, including proposals for short-term actions; provide estimates of consequences, costs and benefits; set priorities; define implementation mechanisms and analyze the implications for nations in different stages of development.

The efforts of the Response Strategies Working Group will be coordinated by a steering committee to ensure that priority tasks are carried out. For example, the steering committee will prepare on behalf of the working group the response to a request from Working Group I for an early reporting of greenhouse gas emissions scenarios to form the basis for climate modeling. The scenarios to be explored are for an effective doubling of atmosphere CO_2 by 2030, 2060, 2090.

Such a 100-year perspective is needed so we can try to determine what our climate future holds, whether that future is acceptable, and how it might be modified. Furthermore, we need to know if time might be bought by short-term actions, such as a complete phasing out of CFC manufacture.

As Chairman of Working Group III, I had the pleasure of introducing Secretary Baker before his first statement in an international forum. The Secretary made four key points: First, we can probably not afford to wait until all of the uncertainties have been resolved before we do act. Time will not make the problem go away.

Second, while scientists refine the state of our knowledge, we should focus immediately on prudent steps that are already justified on grounds other than climate change—things we will never regret, no matter whether global warming ever occurs. These include reducing CFC emissions, greater energy efficiency, and reforestation.

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Third, whatever global solutions to global climate change are considered, they should be as specific and cost-effective as they can possibly be.

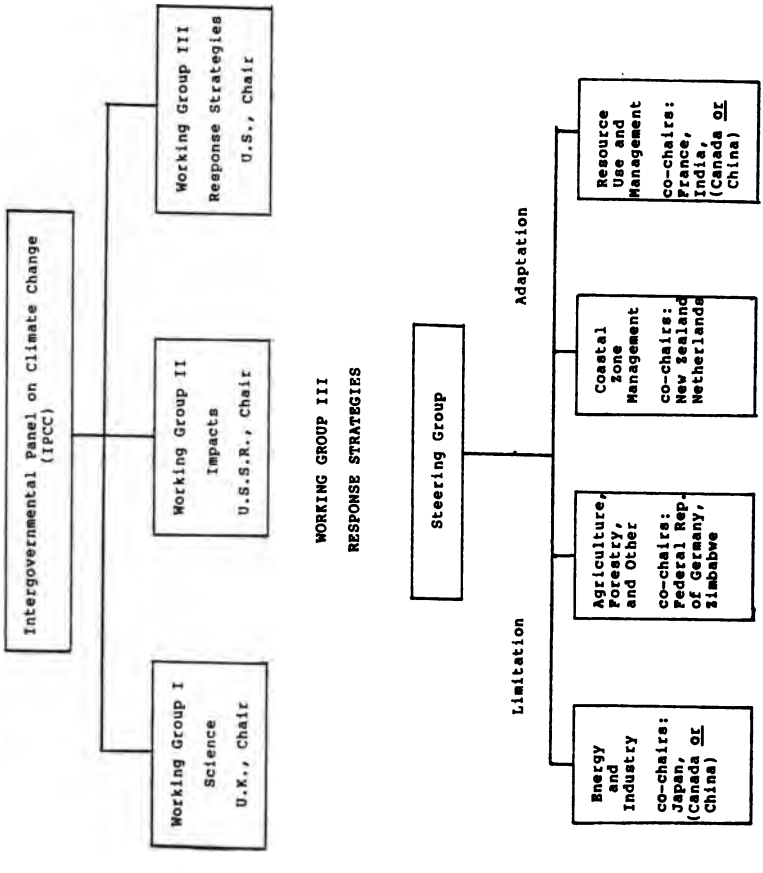
Finally, those solutions will be most effective if they transcend the great fault line of our times—the need to reconcile the human imperative for both economic development and a safe environment.

That the U.S. must play a major role in the understanding and resolution of this problem is inescapable. Any significant change in global weather patterns would affect our climate and socio-economic structure too. Any measures that might be adopted internationally to respond to climate change would heavily influence our economic and political interests.

Further, to the extent that there is a problem, we are a major contributor, as the largest single consumer of energy and emitter of CO_2 (about one quarter of all anthropogenic CO_2). Finally, we have much of the scientific expertise necessary to understand the situation, and the technology needed to respond if necessary.

So one of our first tasks is to achieve a better scientific understanding of what is actually occurring, and what the effects might be. At the same time, under the program set forth by the IPCC, we are beginning now to identify and examine our options for responding to what may become a major environmental and foreign policy issue of the 21st century.

In sum, improving our ability to understand and to predict global changes, whether natural or human-induced, is essential for providing our nation with a sound basis for developing policies and response strategies. The proposed legislation to enhance the effectiveness of the federal research program supports this effort.



The CHAIRMAN. Very good.
Dr. Corell.

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STATEMENT OF DR. ROBERT CORELL, ASSISTANT DIRECTOR FOR GEOSCIENCES, NATIONAL SCIENCE FOUNDATION

Dr. CORELL. Good morning, Senator Hollings, members of the committee. It is a real pleasure to be here and to have the opportunity to talk with you.

I appear on behalf of the Committee on Earth Sciences (CES). I want to thank you for the opportunity that you have provided for this Committee to testify on global change research and more specifically and particularly S. 169.

CES is the principal interagency vehicle for the planning and coordination of the U.S. Global Change Research Program, a program that has evolved over the past year that specifically seeks to establish the scientific base for national and international policy making related to natural and human-induced changes in the global earth system.

The program is described in a special document that was submitted to the Congress as a part of the President's fiscal year 1990 budget. It is entitled "Our Changing Planet—A Strategy for Global Change Research."

"Our Changing Planet" is appended to this testimony as it outlines and provides an overall strategy for a coordinated U.S. interagency effort to do several things.

First, it establishes long-term goals and objectives for a research program. It highlights the specific areas that are to be included in that research. This research program consists of a program of scientific research to understand global scale processes, observation and data management and modeling. Further, it outlines the President's fiscal year 1990 budget requests, with background information on the fiscal year 1989 program and budget.

Mr. Chairman, the CES represents an exciting new development in interagency cooperation and coordinated planning. It provides for implementing an unprecedented program of national and international scientific research to address global environmental change.

The earth's environment is a dynamic system which changes on many times scales and over many spatial distances. Although there is much uncertainty about the relative contributions of both natural and human-induced activities, we are beginning to understand the role of each.

It is vital that scientific understanding of the earth's system be obtained on global scales, including describing how the component parts of the system work. We must know how they interact with one another, and how they are expected to evolve over time. We must improve our ability to predict future changes and states of the earth system.

As a beginning for the testimony, we would like to provide an overview of some recent research results that are improving our understanding of global change and to describe a few of them for you very briefly.

As is already evident by our discussions this morning, much of the public interest in global change has been focused on greenhouse gas accumulation and the associated threat of warming.

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While there is yet much to understand, research is providing an understanding of several new aspects of the greenhouse effect.

There are some things which we now know with great certainty. There are many others that we poorly understand. There is much discussion about the prospects of the potential doubling of carbon dioxide in the next century or so. It is clear that the atmospheric abundance of carbon dioxide is increasing due, we think, largely to the use of fossil fuels.

Like carbon dioxide, the existence of other greenhouse gases is also well known. Methane, chlorofluorocarbons, CFC, ozone in the lower atmosphere and nitrous oxide all play similar roles as CO_2. Their abundance is also increasing in the atmosphere. The reason for the increase of these other radioactively active gases is clearly not well understood.

For example, the sources of methane are not clear, but we know that there are biological mechanisms as well as physical processes that relate to their abundance. While the future abundance of these gases cannot yet be reliably predicted, it is clear that they can add substantially to the greenhouse effects produced by carbon dioxide.

Fundamental understanding of the radiation physics of selected trace gases is increasingly well understood. These above-mentioned gases reduce the loss of outgoing thermal radiation to space thereby increasing the re-radiation back towards the surface of the planet, hence the greenhouse effect.

If the physics of the problem were as simple as just calculating the simple physical effects of the greenhouse process, then the eventual response of the climate system to the greenhouse forcing from radioactively active gases would be, on the average, global warming.

Unfortunately, predicting the net overall response of the climate system is a much more difficult task. Several key processes that govern that response are much more complex than our current understanding reveals.

For example, the effects of clouds and their ability to reflect radiation is not clearly understood. In fact, many of our models did not take that into effect. It was not known whether clouds had a net warming or a net cooling effect for the earth, though our general circulation models have assumed that there is a net warming effect.

Recent analysis (in the January issue of Science) indicates that studies of both long and short wave radiation taken from earth observing satellites now show, for the first time, that clouds have a localized net cooling effect on global climate. Although this finding is based on only a few months of observations, it gives us some insight and it provides us with some preliminary evidence that clouds exert a negative feedback or a cooling effect on climate.

This cooling effect has not been well understood, and, in many cases, was not included in our global circulation models. It is a new insight. Over the past year we have had a number of these new elements that will improve our modeling capabilities.

It is the interactive effect among several earth system processes (including both positive and negative feedbacks), that control the

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overall greenhouse process. Taken together, these processes will determine a new equilibrium, a new state for the climate system.

And we are just beginning to understand cloud physics and cloud dynamics. It is not purely a simple physical and chemical process. It, in fact, involves biology as well.

For example, one recent finding suggests that an important source of cloud condensation nuclei, particularly over the ocean, appears to be dimethylsulfide [DMS]. DMS is produced by oceanic phytoplankton and oxidizes in the atmosphere to form sulfate aerosols around which form the nuclei for clouds. Thus, biological process in the oceans can significantly influence the regulation of climate through changes in cloud dynamics.

In fact, it is even more complex. As you can imagine, temperature changes and the amount of sunlight will control the abundance of phytoplankton which, in turn, produces the DMS, which, in turn, has the feedback effect on the climate system.

So, we are beginning to introduce these more complex processes into our computer models, which should increase our capacity to predict more accurately the temperature trends on the globe.

These research results are beginning to enable scientists to determine the magnitude of anthropogenic effects compared to the natural variability. This, however, is a very challenging task.

The reliability of some of the temperature records, both global and regional, have been questioned, as was noted in earlier testimony this morning.

For example, on regional scales, recent analysis of over 100 years of records from about 6,000 U.S. weather stations shows that there is no statistically significant evidence of an overall increase in annual temperature or change in annual precipitation. This, too, was recently reported in January (the Geophysical Review) and reported in the New York Times and elsewhere.

Thus, there still remains a difference of opinion in the science community. I think these are legitimate differences, because we have not yet clearly obtained the data to support a definitive conclusion.

Understanding the future will be greatly advanced by understanding global scale processes. More particularly, we need to observe the processes in the future and to study the past for historic data which will allow us to unravel natural variability, and to determine the human-induced changes. Tree rings, ice cores, sedimentary records from the sea floor and lakes, pollen sequences in lake sediments, et cetera, all provide us with archives, a library of the past and record of natural change. It is from this historic context that we will be able to more clearly understand the role that man has on global processes.

I think you can see from just these short glimpses that we are making progress and that our current understanding is increasing.

What, then, are we, the science community and the science-interested agencies of federal government, doing about this critical need?

First, as I indicated in my opening remarks, "Our Changing Planet—A U.S. Strategy for Global Change Research," is an effort by the U.S. Federal agencies, in cooperation with the National Academy of Sciences and our international partners, to implement

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a coordinated plan for action, which seeks to understand and predict global changes.

As a follow-up to this initial document, submitted only a few weeks ago, we plan to publish a global change research plan as an integrating document for FY91 Budget planning. It is our intention to have this available in April. It will seek to address the simple question: What scientific knowledge is required to more fully understand and hence to predict future change reliably?

"Our Changing Planet" outlines the framework. The research plan will outline the details. It will propose efforts to answer questions like: What are the roles of agencies, what is the character of our existing programs, and wherein lie their weaknesses? What are the important priority questions that must be addressed in order to unravel this complex problem, layer by layer, until we begin to more clearly understand the dynamics of global change processes?

In cooperation with the Academy of Sciences, we have agreed on seven scientific areas that form the intellectual framework for our Research Plan.

The first element is concerned with biogeochemical dynamics, which is the essence of understanding the dynamics of CO2, methane, and other greenhouse gases.

The second element addresses ecosystem dynamics. It is imperative, we believe, that we improve our current understanding of not only the effect of global changes on ecosystems (i.e. productivity, distribution, biodiversity) but the inverse as well. What is the role that ecosystems have, such as DMS, on climatic processes?

The third element of the program focuses on the physical climate and the hydrologic system. It has been stated that the hydrologic system; i.e., the movement of water and its energy is the "lifeblood" of the climate and global system. An accurate prediction of the magnitude and the change of these mass transfers and energy dynamics is an important component to understanding climate.

We have introduced a fourth element, human interactions, which is an analysis of how human activities impact global change and how those changes, in turn, contribute to the human dimension of life on earth.

Research in this area will include such things as land use change, urbanization and the conversion of land to agriculture, and other human activities which either directly or indirectly change the fluxes that produce the greenhouse effect and influence other dimensions of global change and climatic processes.

The fifth element has to do with the paleo record, the unraveling of the past environmental history of the planet. We called it earth system history. We seek to understand the way the earth has behaved over past decades, centuries, thousands, tens of thousands and even the millennia. For it is in that background that we can then model the present.

A sixth element deals with solid earth processes. There are strong episodic events that have profound effect on the climate system: earthquakes, landslides, vulcanism, sediment movements, and a whole host of earth processes that contribute to climate and global change.

And finally, Mr. Chairman, we have included solar processes which are important contributors to the natural balance within the

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system. It influences the chemical composition of the atmosphere, and its dynamics. It is, in a sense, the ultimate energy source that provides the energy exchange in solar-terrestrial processes.

The plan that we have put forth to the Congress brings together the resources of all the relevant agencies and offices of the United States Government in cooperation with the National Research Council and its Committee on Global Change. And further, that Committee has established liaison with 14 other boards and committees of the National Academy of Sciences so that we have interactions not only with the Committee on Global Change, but bodies like the Ocean Studies Board, the Atmospheric Board, and others.

Secretary Bernthal has mentioned the international aspects. I would like to mention that virtually every major program that is currently underway has international dimensions and international cooperation built into it. From an overall perspective, the US/GCRP is set within an international framework for implementation, including the scientific planning.

It involves direct cooperation with many countries in executing programs, such as the World Ocean Circulation Experiment (WOCE), TOGA, GOFS, et cetera. Virtually every existing and planned program is shared with our partners abroad. As Secretary Bernthal indicated, it is impossible for us to undertake this task alone, not only because of the financial limitations, but this is a problem of the globe and all the nations therein.

The CES is committed to working together amongst the agencies to provide a sound infrastructure and framework for a U.S. Global Change Research Program. This framework is built on three assumptions: broad interdisciplinary and interagency cooperation and a broad sense of ownership across the agencies and across the scientific community.

We seek to maintain scientific independence within the policy framework. This is essential to the far-reaching policy decisions that have economic and foreign policy implications.

In my prepared testimony, I have discussed the relationship of the U.S. Global Change Research Program and the National Climate Program. You and others have asked us about this. During the past few months, we have been working closely with the National Climate Program staff, the NCP Policy Board, and the Congress. During the weeks ahead, we believe that we can articulate a framework for the marriage of these two programs.

Finally, a few words about the bill before us, the National Global Change Research Act of 1989, S. 169. In our opinion, it represents an important step in recognizing the recent efforts by the FCCSET and the Committee on Global Change. The member agencies of CES have, we believe, over the past year demonstrated a real commitment to a coordinated interagency effort to design and implement a U.S. Global Change Research Program, the essence of which is outlined in "Our Changing Planet."

The CES has reviewed S. 169 and endorses the specific responsibilities assigned to FCCSET in the bill. We suggest a few modest changes, and those are submitted in the written testimony.

We believe that the National Global Change Research Act of 1989 will represent an important element for ensuring the nation's commitment to a strong scientific program to observe, understand

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and ultimately predict with reliability the changes that are occurring in the global environment.

This legislation should further assist the nation in establishing a sound scientific basis for national and international policy making with respect to both natural and human-induced changes in the global earth system and more particularly in climate.

It has been a privilege to speak to you this morning, and I thank you for that opportunity on behalf of my colleagues in CES.

[The statement follows:]

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STATEMENT OF

ROBERT W. CORELL
NATIONAL SCIENCE FOUNDATION

REPRESENTING

THE COMMITTEE ON EARTH SCIENCES
OF THE FEDERAL COORDINATING COUNCIL
FOR SCIENCE, ENGINEERING, AND TECHNOLOGY

BEFORE THE

SENATE COMMERCE, SCIENCE, AND TRANSPORTATION COMMITTEE

February 22, 1989

Mr. Chairman, on behalf of the Committee on Earth Sciences, I want to thank you for the opportunity to testify today on the subject of global change research, and more particularly S.169. I am here on behalf of the Committee on Earth Sciences (CES), a Committee of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). This interagency Committee is the principal forum for setting the broad U.S. priorities in the Earth Sciences and the integration and coordination of the U.S. research programs. The CES is the principal interagency vehicle for the planning and coordination of the U.S. Global Change Research Program. Specifically, the Committee's goal is:

> "To establish the scientific basis for national and international policymaking related to natural and human-induced changes in the global earth system"

This program is described in a special document submitted to the Congress as a part of the President's FY 1990 budget. This CES report, entitled "Our Changing Planet" is appended to this testimony, as it outlines an overall strategy for this coordinated interagency scientific research program. In summary, "Our Changing Planet" describes:

- The long-term goals and objectives for the program,
- The scientific areas that are included in the research,
- The essential research observation, data management, and modeling activities that are essential to the program, and
- The FY 1989 and 1990 budget levels, and a description of agency programs in those fiscal years.

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A SCIENTIFIC SETTING FOR OUR NATION'S INTEREST IN GLOBAL CHANGE

The Earth's environment is a dynamic system that changes on all time and space scales. Although there is much uncertainty about their relative contributions, both natural phenomena and human activities may be influencing these changes. It is vital that a scientific understanding of the Earth system be obtained on a global scale by describing how the environment's component parts and their interactions have evolved, and how they may be expected to evolve in the future on all time and space scales.

Specifically, the immediate challenge is to understand the basic mechanisms and interactions and ultimately develop the capability to predict natural environmental changes and to see if there are others which may be influenced by man. Wise policy-making requires this improved scientific understanding of our planetary life support system.

As a beginning point for our testimony, we want to provide an overview of the research required to improve our knowledge of Global Change and to describe some recent research findings.

SCIENTIFIC FINDINGS AND PROGRESS IN UNDERSTANDING GLOBAL CHANGE

Much of the recent public interest in global change has focused on greenhouse gas accumulation and associated threat of warming. While there is much yet to understand, research is providing an understanding of several aspects of the greenhouse effect. Some things are known with high certainty; many remain very poorly understood. We have all heard much about the prospects of a potential doubling of carbon dioxide in the next century or so. It is clear that atmospheric abundance of carbon dioxide is increasing, due, we think, largely to the use of fossil fuels.

The future rate of increase will depend strongly on (i) technical developments, economic factors, and policy decisions, which will be difficult to predict, (ii) the net uptake of carbon dioxide by vegetation and the oceans, about which scientific understanding is still uncertain, and (iii) the net effect of interactions among all elements of the earth systems, including potential feedback responses. Nevertheless, scientists are increasingly in agreement that a doubling of carbon dioxide abundance is likely to occur within the next century.

Like carbon dioxide, the existence of other greenhouse gases is well known. Methane, chlorofluorocarbons (CFC's), ozone in the lower atmosphere, and nitrous oxide are also greenhouse gases. Their abundances in the atmosphere are also increasing. The reasons for the increases are only partially clear. The CFCs are

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industrially produced. However, the sources of the other gases, such as methane, are not as clear, the biological mechanisms for their emission characteristics being particularly ill-defined at present. While the future atmospheric abundances of these gases cannot be prodicted reliably yet, it is clear that they would add substantially to the greenhouse effect produced by carbon dioxide.

Fundamental understanding of the basic radiation physics of selected trace gases is fairly well understood. The above-mentioned gases act to reduce the loss of outgoing thermal radiation to space, thereby increasing the radiation back toward the surface of the planet. If the physics of the problem were as simple as just calculating the simple effects of the greenhouse process, then the eventual response of the climate system to this greenhouse forcing would likely be, on the average, a global warming of the earth. Unfortunately, predicting the net response of the climate system is a much more difficult task. Several of the key processes that govern that response are much more complex than our current understanding reveals -- for example, the effect of clouds and their ability to reflect radiation.

Until recently, it was not known whether clouds have a net warming or cooling effect on the earth (though general circulation models usually assumed they had a net warming effect). A recent analysis of short- and long-wave radiation observations taken by earth-orbiting satellites show for the first time that clouds have a net cooling effect on the global climate. (Science, Vol., 243, No. 4887, January 6, 1989).

Although this finding is based on only a few months of observations, we now have preliminary evidence that on the global scale clouds exert a "negative" feedback or cooling effect on climate. This cooling effect has been significantly underestimated in current models. However, on regional scales, clouds may heat or cool depending on a variety of factors. A possible "positive" feedback mechanism involves ice and snow which melt during warmer periods and may expose darker surfaces. These surfaces absorb more radiation and add to the warming. It is the effect of the interactions among all earth system processes, including positive and negative feedbacks, that determine the new equilibrium climate state that the planet will reach after an increase in radiative forcing by the greenhouse gases.

We are just now beginning to understand that cloud dynamics involves the interactions of physical, chemical, and biological factors. For example, one of the major sources of cloud condensation nuclei over the ocean appears to be dimethylsulphide (DMS). DMS is produced by phytoplankton in sea water and oxidizes in the atmosphere to form a sulphate aerosol. Because the reflectance of clouds (and thus the earth's radiation budget

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issues mentioned above) is sensitive to the density of these condensation nuclei, biological factors in the ocean can contribute significantly to the regulation of climate. However, like the clouds themselves, there is a feedback process in effect because temperature and sunlight influence phytoplankton production and, in turn, dimethylsulfide production. Ice core records indicate that this effect seems to be present in the paleoclimatic record [excerpted from Charlson et al., Nature 326, 655-661; Legrand et al., Nature 334, 418-420]. Introducing these complex processes into our computer models should increase our capacity to begin to predict more credibly the global temperature trends due to greenhouse gases.

Current models predict that, due to the greenhouse gases that are already in the atmosphere, the global average surface warming should be in the range 0.5 to 1 degree Celsius. Has that warming been seen in the temperature record? The answer is not clear. While the surface temperature record shows that there may have been an increase of that order of magnitude over the past several decades, the pattern of the increase - one relatively rapid increase in the 1920's and another in the 1980's - does not match that predicted for the greenhouse effect, which would suggest a more gradual increase in temperature. Therefore, there must be other, presumably natural, processes at work which can influence temperature changes of a fraction of a degree Celsius or larger and which are not considered by present models. Our models do not explain past observations, so it is hard to use them to predict the future.

As a consequence, scientists are searching for a 'signal' whose magnitude is likely to be comparable to the natural variations of the climate system. This is a challenging task. Furthermore, the reliability of some of the temperature records, both global and regional, have been questioned, adding another complication. On the regional scale, for example, a recent analysis of about one hundred years of temperature and precipitation records for about 6000 U.S. weather stations shows no statistically significant evidence of an overall increase in annual temperature or change in annual precipitation for the contiguous United States between 1895 and 1987 (Geophysical Research Letters, Vol. 16, No. 1 pages 49-52, January, 1989). Thus, the current differences of opinion among scientists as to whether there is now a greenhouse warming are substantial.

One final thought on this issue of the climate aspects of global change is that current models are not yet sufficiently realistic representations of the global system to yield reliable predictions of climate features on regional scales. Similarly, they cannot predict the climate of a particular year. This means that the models cannot say whether the U.S. midwestern drought of 1988 was due to the greenhouse effect, nor can they predict the climate features of the next few years. Finally, current models

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are much better at predicting globally average temperatures rather than other climatic measurements (such as precipitation; soil moisture; and year-to-year variability, frequency and magnitude of extreme events) which are crucial to estimating impacts of climate change.

Understanding the future will be greatly enhanced by understanding the evolution of global changes in the past. More particularly, study of the past record of change will assist in establishing the natural variability so that human-induced changes can be placed in realistic perspective. Tree rings, ice cores, sedimentary records in the ocean floors, pollen sequences in lake sediments, insect remains, and other archives of past change, provide the means for establishing the historical record of natural changes.

For example, diagnostic studies suggest a strong link between the low sea surface temperatures in the equatorial Pacific, the 1987 El Nino, and the 1988 North American drought. This may prove to be an example of how equatorial air-sea interactions influence mid-latitude climate. [K. Trenberth, NCAR] This also indicates that the 1988 drought is explainable without appealing to greenhouse warming.

Through the international study of interannual variability in the Tropical Ocean and the Global Atmosphere (TOGA), major advances in our understanding of the relationship between the El Nino and the Southern Oscillation (ENSO) and its climate implications have been made. We have improved substantially our understanding of the processes that control the heat balance in the equatorial central Pacific, particularly the maintenance and long-term variability of the eastern "cold tongue" and the western "warm pool". Further, we know much more about the oceanic currents in this critical region, which in turns is enhancing our knowledge of the total ENSO process.

This is only a small sampling of recent findings that contribute to an increased understanding of global change processes. The assessments I mentioned above should provide all of us with a more detailed understanding of the current state of knowledge of the climatic aspects of global change. I think you can see that progress is being made, but that our current understanding of the processes that dominate global changes is still limited. What then are we, the science community and the science-interested federal agencies, doing about the critical need to increase substantially our knowledge base?

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PLANNING THE FUTURE SCIENCE

A long-term program strategy is described in "Our Changing Planet". The CES is now working on the next planning stage: describing the complex web of science that contributes to our understanding of the global environment and how to implement such an integrated national research effort. We plan to complete the first U.S. Global Change Research Program Research Plan sometime in the Spring of 1989. It will principally address the question:

"What scientific knowledge is required to predict future change reliably ?"

"Our Changing Planet", which outlines the U.S. Global Change Research Program, structured the Program around seven scientific elements. The Research Plan will detail the types of research activities that are needed to reduce current scientific uncertainties about global change in each of the seven elements, and place the research needs in a priority framework. A summary of our current thinking about these areas of research follows:

Element 1---Biogeochemical Dynamics

An essential element of predicting climate change is understanding changes in the atmospheric abundance of the radiatively and chemically active species such as CO2, CH4, N2O, the halocarbons, sulfur and nitrogen species. This will require an improved understanding of (i) the geophysical and biological processes that control the fluxes of these species into and out of the atmosphere, from the aquatic (primarily oceanic) and terrestrial biosphere, the spatial distribution of each ecosystem, and how the geophysical and biological processes and the areal extent of the ecosystems might be altered with a changing climate; (ii) how the fluxes of nutrient species (C, N, S, and P) within, and between, ecosystems are controlled today, and with a changed climate, because the fluxes of these nutrients will influence biological productivity and hence the fluxes of trace gases into, and out of, the atmosphere; and (iii) the atmospheric transformation processes of these gases which control their atmospheric lifetimes and hence abundances. While policy options may exist for controlling the atmospheric abundances of gases such as the CFCs and CO2, they do not exist for gases such as CH4 and N2O because the underlying cause(s) for their current increases are not known.

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Element 2---Ecosystems Dynamics

It is vital that we improve our current understanding of how the productivity and distribution of terrestrial and aquatic (primarily oceanic) biota might respond if there is a changing climate and to other anthropogenic and natural forcings. This is especially important in a period when other factors may be changing, e.g., atmospheric carbon dioxide abundances, ultraviolet radiation levels, the chemical composition of precipitation, and tropospheric ozone concentrations.

Changes in the areal extent and productivity of ecosystems may have several effects on the climate system, including: (i) changes in regional hydrological cycling; (ii) biogeochemical dynamics including the fluxes of trace gases into and out of the atmosphere; (iii) the exchange of energy and water with the atmosphere; and (iv) albedo. Similarly, the type of distributions of biota reflect the dynamics of the climate system. An improved understanding of how both managed and natural ecosystems function and how they might be impacted by changing environmental conditions and societal actions are necessary when considering possible policy response strategies in the event of global change.

Element 3---Physical Climatic and Hydrologic Systems

An accurate prediction of the magnitude and timing of a change in climate (changes in the patterns of temperature, precipitation and severe weather) is limited because of a significant number of uncertainties in our understanding of the physical climate system, including: (i) how the extent and distribution of clouds may respond to a change in the radiative forcing of the atmosphere, or to a change in the aerosol loading of the troposphere; (ii) how the exchange of energy and trace gases between the ocean and the atmosphere may change, especially if the circulation patterns of the ocean change; (iii) how the exchange of energy, water, and trace gases will be impacted by changes in albedo (if there are changes in land cover, and the extent of sea and land ice) and terrestrial vegetation; and (iv) how the climate and hydrologic cycle will interact.

Element 4---Human Interactions

An analysis of how human activities may have changed the climate forcing functions in the past would contribute to an improved understanding of how the Earth's system has changed and how these changes compare to natural variability. This would include an analysis of: (i) major land-use changes such as historical urbanization and conversion of land for agriculture; and (ii) any human activities which may have directly, or indirectly, changed the fluxes of radiatively active trace gases, and how

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social and economic policies influence these changes. Another key set of questions which needs to be addressed include: How would changes in regional and global climate impact human health, and energy, land use and agricultural, natural resource, and coastal zone management.

Element 5---Earth System History

Two key questions currently being asked are: (i) is the Earth's climate currently changing, and is it outside of expected natural variability and (ii) what is the reliability of the predictive models? To answer the first question requires a quantitative measure of the natural variability of the Earth's climate over both short (decades to centuries) and long (millennia) time periods. The natural variability of the Earth's environment over long time scales can be deduced using a number of indicators, including tree rings; ice cores; lake, terrestrial and marine sediments including deep sea cores; and geomorphic features. The texture and composition of soils reflect the climatic conditions under which they developed.

Consequently, soil characteristics need to be mapped on a regional scale using in-situ and remotely-sensed data. Paleoceanographic reconstructions of circulation patterns can be improved by deep sea drilling, and paleogeographic reconstructions of bathymetric and continental configurations can be used to study the interaction of topography, bathymetry, and climate. This historical record of the Earth's environment can also be used, within limitations, to test our models' ability to rationalize how the Earth's system should have responded to changes in the climate forcing functions on timescales of decades to centuries.

Element 6---Solid Earth Processes

Solid earth processes are concerned with active tectonic processes such as earthquakes, landslides, volcanism, sea level changes, and sediment movement that lead to changes in surface landforms and their concomitant effect on global variations. Changes in amounts and distribution of surface runoff and standing water, changes in aerosol, particulate, and chemical loading into both oceans and atmosphere, and changes in the chemistry of weathering and soil development are all affected by the active processes. Studies should focus on the magnitude of these effects, the natural limits of variation before changes become measurable, and the frequency of reaching these limits over a geologic time scale.

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Element 7---Solar Processes

Solar variability is a major contributor to natural changes in the radiative balance, chemical composition, dynamics, and ionization of the atmosphere. Solar energy input to the planet varies significantly over a wide spectrum of time scales, e.g., 27-day solar rotation cycles and 11/22 year sunspot cycles. To understand the impact of solar variability on the climate system, it is important to study and interpret the geologic and historical records for changes in climate associated with solar variability, and to monitor present and future solar output in association with monitoring shorter time scale climate variations. In order to interpret the geologic and historical record of solar activity and climate change, carbon-14 production in the upper atmosphere must be more precisely defined. This will require an improved understanding of certain aspects of particle/field coupling between the Sun and the Earth's upper atmosphere.

LINKAGE TO OTHER PROGRAMS AND PLANNING PROCESSES

The Administration's plans for the Global Change Research Program have strong linkages and heritage from other planning processes. From the outset, the CES's planning efforts were closely linked to those of the National Academy of Sciences and National Research Council through their Committee on Global Change (CGC). The CGC, in turn, has established liaison with fourteen other boards and committees in the NAS/NRC structure -- another indication of the breadth of science that is needed for this program.

INTERNATIONAL ASPECTS

The CGC's plans and the CES's also have been linked closely to the International Geosphere-Biosphere Program (IGBP) plans, which have been developed under auspices of the International Council of Scientific Unions (ICSU). This planning linkage needs to evolve into an international forum among nations and the agencies who have the resources to carry out the recommended research program. The CES has introduced some ideas about international science coordination into the ICSU arena for other nations' consideration, but implementation and international coordination forums have not yet been established.

The international dimension of global change also advanced significantly with the establishment last year of an Intergovernmental Panel on Climate Change (IPCC) under auspices of the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). The CES, working with other interagency processes, helped to develop the U.S. science position for the first

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meeting of the IPCC, recommending separate panels for consideration of science issues, likely impacts and response strategies, with the objective of separating science from policy issues, providing a sound scientific foundation for policy evaluation and formulation. At the request of the Department of State, the Committee on Earth Sciences is coordinating the U.S. involvement in the IPCC Science Working Group, which is chaired by the U.K. These efforts should greatly improve our knowledge of the climate component of global change. Secretary Bernthal will say more about the IPCC in his testimony.

ORGANIZATIONAL REQUIREMENTS

The commitment of the CES and of the Global Change Research Program is to provide a sound technical basis for policymaking. In both the national and international arenas, it is crucial to establish appropriate relationships between the organizations responsible for science and those responsible for policy, and to assure that they communicate effectively. The CES is committed to developing the necessary knowledge and conveying it effectively to decision-makers as scientific knowledge develops and evolves. The Global Change Research Program -- the science side of the U.S. global-change effort -- needs to be managed in an institutional framework with the following characteristics:

1. Broad interdisciplinary and interagency representation and sense of ownership.

   The science of global change is enormously complex. Its complexity springs from a major shift in scientific understanding of the Earth's life-supporting environment--a shift that has occurred over the last two decades, but which has accelerated dramatically in the last few years.

   Fundamentally, the change is this: scientists have traditionally studied climate, ecosystems, biodiversity, ocean circulation, and so on, as isolated disciplines, with limited understanding of the impact of one discipline on another or of one part of the earth system on another. As scientists explored environmental processes over longer intervals and greater distances (finally achieving global scales with the advent of satellite observations), however, they found more intimate and complex linkages between parts of the system, and recognized their interdependence.

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All the earth-science disciplines must now collaborate to do effective research on the global environment. Because support for these disciplines is spread across many agencies, the agencies must also collaborate. The Global Change Research Program must be coordinated from a broad, interagency forum; the CES has proven to be effective as such a forum.

2. Scientific independence and objectivity.

Broad trust in the objectivity of the science is essential for the success of policymaking efforts, particularly in international negotiations with far-reaching economic implications. Independent and objective science, therefore, serves both science and policy needs. The Committee on Earth Sciences, as a group of agencies with scientific missions, provides an appropriate science-oriented forum for planning and coordinating the scientific effort.

3. Communication between science and policy forums.

Scientific independence does not imply isolation; for the Nation's interests to be well served by the program, its science-coordinating forum must communicate effectively with policy-formulating forums. The CES can stimulate such exchange, because the members of the CES are agency directors or assistant directors, whose positions allow and encourage them to communicate effectively with the Office of Management and Budget, the Domestic Policy Council, the Council on Environmental Quality, and other appropriate policy bodies.

The Committee on Earth Sciences and the Federal Coordinating Council for Science, Engineering, and Technology are appropriate vehicles for addressing these organizational requirements.

OTHER INSTITUTIONAL ARRANGEMENTS

The relationship between the U.S. Global Change Research Program and the National Climate Program has been raised by your Committee and by others. During the past months, there has been extensive study of this issue, I would like to outline the status of those considerations.

The National Climate Program (NCP), established by the National Climate Program Act, has led much of this Nation's early interest and program development in research and science policy related to climate. We recommend that the National Climate Program be a major part of and significant contributor to a broad U.S. Global Change Research Program. More specifically, we

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recommend that the CES and the National Climate Program Policy Board work with your Committee and its staff, along with the cognizant Committees with oversight responsibility for the National Climate Program Act to draft the necessary language to assure effective cooperation between the U.S. Global Change Research Program and the NCP.

NATIONAL GLOBAL CHANGE RESEARCH ACT OF 1989

The National Global Change Research Act of 1989, S. 169, represents an important step in recognizing the recent efforts of the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) to coordinate Federal global change research though its Committee on Earth Sciences. The member agencies of CES have, over the past year, demonstrated their commitment to a coordinated, interagency effort to design and implement a U.S. Global Change Research Program, the essence of which we have presented to you in this testimony, and through the strategy for this program, which is attached.

The CES has reviewed S. 169, and endorses the specific responsibilities assigned to the FCCSET in the bill. We believe, however, that several amendments will ensure that the legislation and the interagency coordinating mechanism it codifies reflect more closely the current deliberations of CES. Mr. Chairman, we offer these as suggestions, and would be pleased, if asked, to work with you and your staff in adapting them to the bill.

First, references to agency participants throughout the bill should reflect the current membership of the CES. Specifically, this will require the addition of the Departments of State, Agriculture, and Transportation. They continue to be involved in the work of the Committee and should be recognized participants in the efforts of the FCCSET to develop a national global change research plan, and to assist in its implementation. In addition, the Smithsonian Institution has recently become a member of the CES.

Second, we suggest that Section 602(d) be amended to reflect the agency research role statements currently being developed and approved by the CES and all the participating agencies and bodies. We have undertaken this responsibility to clarify the agency roles for a global change research program, so that complimentarity and effective meshing of agency roles underpin the program. We expect full Committee approval of these role statements within the next month, and can provide you with the language adopted at that time.

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Third, we would recommend modifying 603(b) such that research findings are made available to all agencies and departments to help them modify policies to meet their statutory responsibilities and obligations were climate to change, or to deal with the climate change issues.

Fourth, as mentioned earlier, we would also like to work with all appropriate committees and staffs to draft the necessary language to effectively integrate the U.S. Global Change Research Program and the National Climate Program.

Fifth, the current language in section 602(b)(3) has the effect of placing the Council in the budget formulation process which is an area best left to the agencies themselves. We would recommend deleting this sector or substituting the following language: prior to the submission of an agency's budget to the Office of Management and Budget, the Council shall provide the interagency forum to ensure that agency programs are developed in the context of the Plan.

Sixth, it is unrealistic to request explicit funding requirements of a ten-year program. We recommend deleting the reference to Federal funding in Section 602(a)(2)(C) and substituting that annual budget estimates will be submitted to the Congress that reflect the activities outlined in the ten-year research plan.

Finally, we recommend deletion of the specific term "basic" as a modifier for research throughout the text. The term "basic" and its counterpart "applied" carry specific technical implications as part of annual reporting requirements for Federal R&D activities. Those definitions result in much mission-directed research, like that of the National Oceanic and Atmospheric Administration for example, being reported as "applied"--including research which is identified as important elements of the U.S. Global Change Research Program. Removal of the term "basic" as a qualifier in the text of S. 169 will ensure that the legislation applies to all necessary and essential elements of mission-directed agencies which might otherwise be considered "applied" research.

We believe that the National Global Change Research Program Act of 1989 will represent an important element for ensuring this Nation's commitment to a strong scientific program to observe, understand and predict changes in the global environment. This legislation should further assist the Nation in establishing a sound scientific basis for national and international policy-making related to natural and human-induced changes in the global earth system.

We would note that the language of section 602(e) will be carefully reviewed by the Administration to ensure that it conforms with current law and agency responsibilities in the conduct of international science and technology policy.

Thank You.

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The CHAIRMAN. Thank you very much, Dr. Corell. We are going to use the clock this morning because we want to get around to all of the participants here.

I am interested in organization, I am interested in money, and I am interested in setting an example. Secretary Bernthal, Dr. Corell has listed a few minor amendments in support of S. 169 which I think are well taken. Do you find any other conflicts with this particular bill? We are trying to get in step with the administration. Does this bill put us in step with you or not?

Mr. BERNTHAL. Yes. I believe broadly speaking, Mr. Chairman, we see no difficulties with the bill. The administration is supportive of the bill and as my written testimony indicates in so much more detail we are supportive of the details that Dr. Corell has indicated.

There was one element of scrutiny that we felt was warranted that is also indicated in my testimony, and that was a clear delineation of responsibility over international science and technology issues.

The CHAIRMAN. Very good.

You have been very thorough, both of you, and very comprehensive and a tremendous contribution.

Let me ask about money because that is one of the things that interested me. I found the same studies and same applications in 13 different budgets. Mr. Secretary, you have seen it overall. Do you have any comment with respect to the allocations of funds within the government?

Mr. BERNTHAL. The OMB has done a fairly careful cross-cutting study of the application of funds in this general area, and I am going to ask Dr. Corell to talk in more detail, if you wish. My understanding is that there is in the neighborhood of $190 million if you cut across all the agencies allocated for these programs.

The CHAIRMAN. Now, is that a waste or is that inadequate? I mean, if you were king for a day, what would you beef up and what would you minimize?

Mr. BERNTHAL. I am going to turn to Dr. Corell as one of the spokesmen at least for the domestic agencies.

The CHAIRMAN. Dr. Corell, what about it?

Dr. CORELL. On page 24 of "Our Changing Planet" is a full spread sheet which outlines the principal agencies involved in this 1990 effort and divides that up into the seven scientific categories that I outlined earlier. Developing that document was a very complex process. I think it was almost first of its type for these agencies, including OMB and OSTP.

[The table follows:]

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Table 1
1989-1990 U. S. Global Change Research Program Budget
(Dollars in Millions)

Focused Program	Total Budget		Biogeochemical Dynamics		Ecological Systems and Dynamics		Climate and Hydrologic System		Human Interactions		Earth System History		Solid Earth Processes		Solar Influences	
	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990
Agency Totals	133.9	190.5	29.8	44.9	28.1	39.5	38.0	59.3	22.0	22.0	3.0	7.0	8.9	10.5	4.1	7.3
NSF	39.2	53.5	13.5	18.3	1.9	1.9	13.2	17.0	0.0	0.0	2.0	4.7	6.2	6.5	2.4	5.1
DOE	20.2	27.2	6.0	5.5	4.2	6.7	7.0	10.2	2.0	3.6	0.0	0.0	0.0	0.0	1.0	1.2
DOI/USGS	5.3	10.3	0.0	0.0	0.0	0.3	2.3	5.0	1.5	2.0	1.0	2.3	0.5	0.7	0.0	0.0
NASA	14.5	21.5	3.0	4.4	4.3	6.4	4.3	6.4	0.0	0.0	0.0	0.0	2.2	3.3	0.7	1.0
DOC/NOAA	9.0	20.0	0.0	3.0	0.0	0.0	9.0	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EPA	27.4	35.3	0.8	3.5	7.4	13.2	0.7	2.2	18.5	16.4	0.0	0.0	0.0	0.0	0.0	0.0
USDA	18.3	22.7	6.5	10.2	10.3	11.0	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Activity	133.9	190.5	29.8	44.9	28.1	39.5	38.0	59.3	22.0	22.0	3.0	7.0	8.9	10.5	4.1	7.3
Research	116.4	158.9	26.9	40.1	24.9	35.0	31.6	46.1	22.0	20.8	3.0	3.5	5.4	8.1	2.6	5.3
Observations	10.7	15.0	0.0	1.5	2.0	2.5	5.0	8.5	0.0	0.0	0.0	0.0	3.5	2.2	0.2	0.3
Data Management	2.3	8.1	0.4	0.8	0.2	1.0	1.4	4.7	0.0	1.2	0.0	0.0	0.0	0.2	0.3	0.2
Facilities	4.5	8.5	2.5	2.5	1.0	1.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	1.0	1.5

In late August we submitted to the OMB (from two perspectives) the budgets for this program. First, we submitted an integrated program which outlined a total effort as documented in the strategy document. At the same time, each of the participating agencies, with full knowledge of the total program and in coordination with each other, submitted their budgets through the normal OMB process. If you were to hold those two documents together, the strategy document and the individual agencies budgets, there was total coherence on every item.

During the fall, the normal period during which budgets are built, all the agencies met together with the cognizant agency examiners within OMB and received the budget. Individual agency programs were consistent with the overall US/GERP budget. If you look at the budget distributions, you will find strong efforts in the climate area, for reasons that are, I think, obvious from the thrust of the hearing.

We are more slowly developing programs in such areas as solar influence and solid earth processes.

Finally, this budget planning is done in the framework of long-term 5 year planning perspective. Each of the agencies has done the five-year perspective. So we are submitting a budget for FY '90 in the context of FY '91 through FY 1993.

If, during the appropriation process you want more details we can supply these. Bottom line, we think, is that this is a rational process to develop the FY '90 budget.

The CHAIRMAN. Quickly, by way of example—you know, I think President Kennedy used that quote about the captain who waits for his ship to be fit and never puts to sea. If we continue planning for ten years and do nothing, we all would agree that would be a mistake. And yet, on the other hand, at the same time, I do not want to go down to Brazil and tell them to quit cutting down the

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Amazon. They would point their fingers and say—you are the ones burning all the fossil fuels, you up in the United States of America.

Is there something we can do by example? As I understand it, an effective international agreement would be more in the nature of a convention along the lines of the Montreal protocol rather than the Law of the Sea. The Law of the Sea Convention was like calling pigs. Everybody came and said—give me a part of the oceans and all the resources. As a result, we have not ratified it. But with the Montreal Protocol we have done a lot better. In that regard, we will have to set an example ourselves. Say, we could enact this bill in the next ten seconds, is there something in addition to the planning that we could be doing this year to set an example, in your opinion, Dr. Corell, and then Secretary Bernthal?

Dr. CORELL. I would like to indicate that planning here is not to outline what we might do in the future, but is an implementation effort. We are fielding the pilot efforts in a number of areas, such as the Global Ocean Flux Study (GOFS).

The Global Ocean Flux Study seeks to understand the transfer of CO_2 and other constituents from ocean to the atmosphere and vice versa. The pilot study is in the North Atlantic. It will commence within about a month.

So, planning here is not to say what we might do. This is an implementation effort and virtually every penny here is designed to go into the field, into computer modeling, and move forward on the scientific agenda. So, it is not a plan in a long-range sense. It is a plan to implement scientific research.

The CHAIRMAN. Secretary Bernthal.

Mr. BERNTHAL. Mr. Chairman, as far as the international effort is concerned, I would just stress the policy emphasis that we put on this IPCC process, the intergovernmental panel, the U.S. worked very hard and very responsibly, in my judgment, to obtain the chairmanship of the response strategies working group. There was a massive interagency process that went on in the midst of a transition of administrations, I might say, and we presented an elaborate, detailed plan to the first organizational meeting of the response strategies working group.

There was considerable lively discussion. The essence of that plan and the framework of it turned out to coordinate well with our existing agencies so they can grab on quickly, whether it is EPA or whether it is Department of Energy, Department of Commerce, Interior and Agriculture, the major domestic agencies now we believe will fit in well with that structure, and there is a similar match, in my judgment, with the subgroup structure that we formed and the response strategy working group for other countries as well.

We also have been very cognizant of the difficulties in one of the areas that you pinpointed, and I understand and was aware of your trip down to Brazil recently. The continuing deforestation not only in Brazil but elsewhere is just a continuing catastrophe. But we have to have practical solutions to offer in this arena, and that is not going to be an easy process.

I must say that there have been beginnings. The idea of debt for nature swaps, for example, has already been suggested. But we have to work with the Brazilian government and with other gov-

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ernments if any of these programs are to succeed. We cannot just be talking to ourselves in our country.

It is worth noting that during our developmental stage in this country, we rather thoroughly devastated the northern forests of our own country to build Chicago. Other countries hasten to point out those kinds of parallels. So, we need to work with countries in what has become a truly international problem to try to address this very difficult issue that you and Senator Gore and others have observed firsthand.

The CHAIRMAN. Very good. Senator Gore.

Senator GORE. Well, thank you, Mr. Chairman. I was not going to start with that question. But since we are discussing Brazil, back when the United States cut our forest, we did not know what all of the consequences might be. And, indeed, the world's population was small enough then and the impacts of human society were small enough then that it really did not matter much.

But there is now a very different situation. More than 10 percent of all the CO_2 put into the upper atmosphere last year may well have come from the burning of the Amazon.

I might just say that I have been working on a small group with Senator Tim Wirth and Senator Jack Heinz. We have had extensive discussions with the Japanese embassy. They have not yet committed to that road to Peru. I hope they will not. There is a lot of misunderstanding about the role of the rain forest in this entire question, and you and I have had discussions about this, Mr. Secretary.

Indeed, many are surprised to find out that tropical rain forests are not net consumers of CO_2 because as climax forests they have balanced CO_2 and oxygen budgets. So, when they are sometimes described as the lungs of the world, that is inaccurate. The forests of the world generally are the lungs of the world, along with the southern ocean around Antarctica, which consumes more CO_2 probably than all of the forest land.

But in any event, I agree that we need to solve this problem on an international basis, and it is going to be very, very tough. I do not know if we are going to have more than one round, Mr. Chairman. I hope so. There is a lot that I would like to cover with these witnesses. But if we are going to have more than one round, I will just start with kind of a general thrust.

I appreciate the research agenda that has been presented here. I have had continuing problems, however, Dr. Corell, with the way in which those who emphasize research sometimes present the problem to policy makers. You are doing a good job. I have no quarrel with it. I am very enthusiastic about the Chairman's bill, and I predict we will pass it quickly.

But, policy makers are vulnerable to seizing upon any uncertainty put forward by the scientific community as an excuse for waiting until all of the evidence is in before acting. And, you know, I hear the business about maybe the earth is cooling instead of warming. I mean, 99 percent of the scientists in this area would reject that view. Would you not agree with that, Mr. Bernthal?

Mr. BERNTHAL. I would agree that the idea that this will lead to a global cooling is outside what I would call the mainstream of sci-

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entific opinion at this time. I still pretend to be a scientist from time to time, but I will ask Dr. Corell his opinion as well here.

Senator GORE. That is pretty far outside the mainstream, is it not, Dr. Corell?

Dr. CORELL. Yes, very much so.

Senator GORE. All right. Now, there are some areas of uncertainty, but it is important to put boundaries around what we know and what we do not know.

Generally speaking there are three areas of uncertainty. First, how would the oceans respond to warming? There is 50 times as much CO_2 stored in the oceans as in all the vegetation on earth. Now, the oceans both absorb CO_2 and disgorge CO_2. What will happen to that CO_2 sink and how is heat energy stored in the oceans? That is one area of uncertainty.

But even there it is important to emphasize that the uncertainty is on the downside as well as the upside. And if you pin down the scientists who specialize in that area of inquiry right now, they would tell you that their gut feeling is that warming of the oceans will probably lead to a net disgorging of CO_2. They do not know yet. But, in other words, that area of uncertainty could lead to a much worse problem than the mainstream middle-of-the-road prediction right now.

Secondly, the second area of uncertainty has to do with the cloud system. Any meteorologist knows that clouds have more of an effect on temperature in the short term than anything else. And might there be some mechanism by which the earth magically generates more cooling clouds in response to these other phenomena that are producing global warming? In other words, is there some kind of magic thermostat that is going to protect us from ourselves.

And, again, every once in a while a scientist pops up and says I think I found it. I think I see it. But every time you look at it, it is not there. It does not hold up. Hopefully we will find one. But, again, the uncertainty there could be on the downside as well.

You talked about the production of DMS for cloud nuclei by phytoplankton. Well, the recent studies indicate that phytoplankton diminish their photosynthetic activity by 80 percent when they are exposed to increased UV radiation, correct?

Now, by destroying the stratospheric ozone layer with CFCs, the concentration of which will double in the stratosphere by the year 2000, we are exposing the phytoplankton to exactly the kind of radiation environment that diminishes the activity that produces DMS. And so, again, the uncertainty in that area could be on the downside as well as the upside.

And the third area of uncertainty is what they call biogenic responses. For example, what will happen when the tundra warms up in the higher latitudes, or, when the reflectivity of the surface, the albedo, is changed dramatically in response to global warming?

You would have a much faster warming and, again, the tentative evidence indicates that when the tundra warms up, there are massive increases in the amounts of methane that are released into the environment. Again, holding out the possibility that the entire problem could be made much worse rather than holding out the hope that somehow we will find this magic thermostat.

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Gosh, my time has run out. This business about the U.S. climate record, God almighty, the lower 48 states represent 1½ percent of the earth's surface. It is utter nonsense to suppose that a 100 year climate record on 1½ percent of the earth's surface is going to somehow give you a clear picture of what is happening to the global climate.

Shortly after going to Antarctica with our chairman and shortly before going to the Amazon rain forest, I went to visit with a team in East Anglia, England that has compiled what many presently regard as the definitive world climate record.

Would you agree, Dr. Corell, that their global climate record, which takes the temperature measurements from ships out in the middle of the ocean crossing the Atlantic and Pacific and goes back more than a hundred years, does, in fact, demonstrate a warming of approximately 1 degree Fahrenheit during the last century on a worldwide basis?

Dr. CORELL. Absolutely. I did not read it in my summary, but it actually is in my testimony as you have described it. We agree completely.

The CHAIRMAN. Senator Kasten.

Senator KASTEN. Mr. Chairman, thank you. Secretary Bernthal, what is the schedule for these different working groups, and are you going to be coming up with interim solutions?

Mr. BERNTHAL. The general schedule that is set down in the short-term, and I emphasize short-term because there is a very long-term schedule as well, is that we hope to have a meeting of the subgroups of our response strategies working group again in the May/June time frame.

There will be an overall plenary meeting of the intergovernmental panel in Nairobi. I believe it is scheduled now for the end of June, and at that time all of the working groups—and mind you, this is in six months time so things are moving fairly quickly.

All of the working groups will be expected to present a progress report on where things stand. For the somewhat longer term, the thrust right now of the IPCC is to be prepared in 18 months to report before the second World Climate Conference toward the end of 1990 on its progress and the general findings of all three working groups.

Now, I say there is a very much longer term plan as well, and it should be stressed that what we are trying to do here is set into place an organism, if you will, a mechanism that is prepared to deal with the scientific questions as they arise, the resolution of those questions, begin now to plan responses but also be able to make midterm corrections well into the 21st century as these issues come up.

Senator KASTEN. Well, I think the Chairman touched on the key question here in terms of once you develop what those response strategies might be, what then is the mechanism by which you can, in effect, enforce or encourage or reinforce, or whatever word you want to pick, certain kinds of activities, whether it is the Brazilian rain forests or other areas.

What, in your opinion, would be the best and the most efficient institution to begin working through these kinds of decisions and possibly these kinds of negotiations? As you know, we have worked

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carefully with you and others in effect through the Inter-American Development Bank, the African Development Bank, and the World Bank, and we have used the leverage, if you will, of U.S. taxpayer dollars that should not be used to subsidize environmentally damaging kinds of projects. By putting that enforcement mechanism through the appropriations process we have been able to make some changes.

We don't have that kind of leverage on any government around the world, and we do not seek it. But what is the next step in terms of trying to get the international cooperation and some kind of an enforcement mechanism and some kind of a decision-making process?

Do you try to do this through your response strategy steering group? Is this the beginning, or are you looking to another international institution of some kind? Or do you think that we would be working through a Montreal protocol kind of a system?

Mr. BERNTHAL. At the outset, the short answer is that the IPCC is in fact charged with carrying out many of the responsibilities that you correctly point to. You are right, there is not a great deal of leverage.

The decisions that were taken by the IPCC in its organizational meeting and indeed in the response strategies working group meeting were by consensus. Not everyone got absolutely everything he wanted in every respect, but by and large there were no dissenting voices at the end of either of those meetings.

I would point to the steering committee task. We pinpointed two things, one of which I mentioned in my testimony, the other of which I would like to illuminate in response to your question.

The first was the request of working group one for some scientific information, or rather scenarios, for emissions into the next century, but the second was indeed to develop a strategy for implementation.

Now we are doing that in parallel with all of the scientific uncertainties that have been mentioned but we feel that that is necessary and generally those strategies are to include the following: a strategy for legal and institutional measures; strategies for public education and information; strategies for technical assistance where that might be needed to respond should we need to limit CO_2 emissions, for example, and financial and economic measures I would assume similar to those which I know you have been working on. And I must say, we have been very pleased by the progress that has been made in the International Development Bank community in that regard.

So in a nutshell, right now the IPCC is the central focus of administration policy in this arena, but other things like implementation mechanisms are indeed being considered by the response strategies working group.

Senator KASTEN. Mr. Secretary, thank you. I just want to say that I think in this whole area we have got science that must catch up, but at the same time this whole next question about even if we had perfect science, which we do not, how would we get from where we are to where we want to go, and with what kind of international cooperation?

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Maybe it is going to be all on a voluntary basis, I do not know, but we have problems not just in the science but in the institutionalization, or whatever you want to call the overall negotiations that are going to have to take place.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you. Senator Kerry.

Senator KERRY. Thank you, Mr. Chairman. Mr. Secretary, you began your testimony today with a reference to the speech that I think President Bush made in Michigan, saying that those who are concerned about the greenhouse effect have not heard of the White House effect. That was followed by Secretary Baker's comments that I alluded to in my opening comments regarding the need to take some action and that research was not necessarily the panacea here.

My question to you: is there a contradiction between your quotations as well as the Secretary's position and the reliance that you have placed here on this formula for study?

Are there a specific set of recommendations that you are prepared to make now, or are considering now which may be made shortly, regarding a revision of the Montreal Protocol, the shifting of the CAFE standards, or a number of other things that you might want to share with us that do not need to wait for further research?

Mr. BERNTHAL. Well, let me address what is the most pressing issue, because as you know there is a meeting that is coming up the first of next month in London that Prime Minister Thatcher has called and that Senator Gore and Bill Riley and others will be attending. That is the issue of the Montreal protocol and the adequacy of it, and the state of the ozone depletion problem.

There is a process that was set in place under the Montreal protocol for scientific assessment, and I must say I was briefed personally by Bob Watson and Dan Albritton last week on what is happening in the Arctic regions.

They are being cautious as to exactly what the implications are. I think they are being very responsible scientists and I would expect that as that information becomes available when we move through the springtime period here, which I understand is key, then they will be prepared according to the plan that is laid out under the Montreal protocol to bring forward at the meeting in Finland a summary of the status of the science, and then there also is a plan in place under the protocol for a formal reassessment of whether there should be a change in the protocol in 1990.

Now, I must say that the scientific evidence that I heard laid out the other day suggests strongly that this problem is not going away, that it may be advancing more quickly than we had believed, and I pressed Dr. Watson rather thoroughly on how closely related the precursors to ozone depletion were to CFC emissions, and he is convinced and others are convinced I think that there is a close relationship.

So the first issue that I would put on the table is the question of the position on ozone. We have a process in place. That process will culminate in one year, and the administration is in the process right now, in fact, of making a determination on exactly what the position will be early in March.

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Senator KERRY. What I hear you saying is you really are waiting for the scientific outcome.

Mr. BERNTHAL. We are waiting in part at least for——

Senator KERRY. How does that differ? Why is the White House effect not a rhetorical effect, then?

Mr. BERNTHAL. Well, let us wait and see what the administration's position is going into the London meeting, and also what further positions the administration might take on this issue. I do not believe it is a rhetorical effect. I think that Secretary Baker's comments and the specifics that he laid out including those things that we ought to be getting about now, whether or not global climate change occurs——

Senator KERRY. No, I understand, and I am not trying to be combative, but there is a contradiction between saying that the time for action is now and the action is awaiting further study. I mean, that is a contradiction.

Mr. BERNTHAL. We are in the process and the frame work of the response strategies working group and we have enlisted almost every technical agency in this government to support that effort. We are in the process of developing policy options right now through the response strategies working group and that is not the scientific effort. That is the policy effort.

Senator KERRY. I wonder if you would clarify for me, in the actual working group meeting that took place in January, U.S. officials and staff positions appeared contradictory. There was a feeling by most people that there was even a contradiction in the working group and the staff approach to what the Secretary had said. Since that meeting there really has not been any clarification on what the policy is. You have essentially clarified it now, saying we are on a sort of action research-oriented path.

Mr. BERNTHAL. Parallel tracks is the way I would characterize it on policy and research.

Senator KERRY. As you recall, during the Montreal Protocol negotiations there was considerable squabbling within the process that almost derailed our efforts. A group referred to as the Rayban Plan group seemed to be having significant effect on the strategy. Do you envision that group affecting this current debate in the same way, or are there even plans conceivably to change the makeup of the intergovernmental panel?

Mr. BERNTHAL. This is a new administration, Senator Kerry, and although not all members of the administration are in place, I think that the president's comments speak for themselves on the importance of a number of these environmental issues.

He has appointed to head the Environmental Protection Agency someone who has built his career in the environmental field, and so I think there is a very strong commitment to deal with these issues.

Exactly what interagency discussions might arise, either in respect to ozone or in respect to global warming, I simply cannot predict right now. I am sure there will be discussions. There will be different points of view, and there will be disagreements. There always are.

Senator KERRY. One last question, if I may. The questions that Senator Gore asked laid out the potential down side of awaiting

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some scientific conclusion, obviously. Are there scenarios based on the science at this point that predicate our taking some action to minimize the down side in a most cost-effective way before that science can be forthcoming?

Mr. BERNTHAL. One of the difficult tasks, and again the policy effort both within our government and within the, I will use the acronym RSWG so I do not have to say it, the RSWG working group, one of the difficult tasks there is exactly that.

To try and set out policies and also to attempt, and there has not been very much of this yet, to attempt to determine the least cost strategies, if you will, for achieving mitigation if that becomes necessary, or reduction in CO_2 emissions, and I will just pick on one issue here and that is reforestation.

It may be that reforestation turns out to be one of the least cost strategies for mitigation. Now, it is not a long-term solution but I have been trying, and I was pleased to hear that at least Dr. Watson from NASA has been trying and others as well, to get a clear fix on exactly what the magnitude of that effort would need to be, and therefore so you can get some clear cost estimates and I simply do not have that right now.

That is one of the things that is the task, though, of this response strategies working group. There are other areas like that that we simply have to set out now to begin to establish price tags.

If we found, for example, that there was a necessity to reduce over a reasonably short period of time, and we are talking maybe the period of one generation, CO_2 emissions, there would at present it seems to me not be a lot of options at our disposal and some of them might be very expensive and we need to know what the cost would be.

Senator KERRY. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Stevens.

Senator STEVENS. Thank you, Mr. Chairman, and I again congratulate you on this. I think the document that Dr. Corell has mentioned setting forth the way that the current appropriations are divided among activities demonstrates the necessity to have sort of an earth sciences initiative as we had in SDI.

You know, when we first went into the whole concept of SDI we found that there were a myriad of agencies that had money that was not coordinated, that was overlapping, and I think you could accomplish the same thing here if you really pursued that same concept of trying to get coordination and control and prevent duplication of research, and so I commend you on this and the administration too.

I am interested in whether our goal really is to develop a very complete database, the best database that is humanly possible to develop, before we take action and recommend initiatives. Is that our goal?

Dr. CORELL. We have evolved what we think is a new way to do business, and Senator Gore properly put this in perspective and you are adding to that.

Historically, we worked in what I call the "serial mode." Science planning occurs within the community and it comes to the federal government some time later and a plan is then put in effect and

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implemented. Later on you get some results, upon which policy decisions occur. So, it is serial in time.

And as Secretary Bernthal indicated, we are operating in a "parallel mode." We are working with the scientific community in detailed scientific planning, at the same time we are developing the framework for implementation.

A year and a half ago we did not have the coordinating mechanisms; we did not have the relationships; but, now, we have brought them side by side and can plan and develop implementations in parallel.

What is happening with the policy framework is the same idea. Insteal of having research results published and then do policymaking, we see a need to work in parallel. The meeting the other day on Arctic ozone intended to get results out immediately.

Those scientists had not been home 36 hours when the report was made available. So we put the latest information into the decision-making process as soon as possible. Secretary Bernthal and his colleagues, as they go abroad for intergovernmental discussion in a few weeks will have the results.

We are trying very hard to move toward this parallel process, a new paradigm for doing business. From the scientific community's perspective, we see the need to constantly feed scientific results into the system so that the policy community can move ahead. I think the three part plan of IPCC is built on the same assumption. Do science assessment, impacts assessment and response strategy in parallel, and move those things when you can.

Senator STEVENS. I am delighted to hear it, because as indicated by Senator Gore here, there is now some change in thinking about harvesting timber from climax forest. I am a provincial, as my friends all know. We have a forest in Alaska, a national forest that is the size of New England.

For several years now, people have tried to prevent the Alaskan industry base from harvesting timber there because it is a climax forest and a rain forest, and some people believe that even cutting one tree from that forest was contrary to the whole best interest of the world as far as the issues you are dealing with now.

Now I understand some people have come back around and understand as my friend indicated this morning that a climax forest is not necessarily the best forest in the world as far as the climate of the world is concerned. We are not confident of that yet, but I am interested in developing the database to make certain of what we do and not have policy decisions made on a genuflect reaction by the Congress without the adequate advice of the scientific community as to what we should do before we change our society.

I am also very interested in the fact that the API now has come forward, the American Petroleum Institute, and supports this bill. I think that is important for us to realize that the whole industrial base of the country wants some answers. They want the database that you are going to develop through this initiative, and I think that is extremely important for us to have.

Tell me about this Arctic ozone group again, and what they have concluded, will you?

Dr. CORELL. Sure. I would be delighted. In fact, I welcome the opportunity to put this CFC thing in a little larger perspective, if you

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would permit me. I talked with Bob Watson and Dan Albritton, who, as you well know, have been the principals in coordinating much of our scientific interest in this country. Here is a quick summary.

The weight of scientific evidence strongly indicates that man-made chlorine and bromine species are primarily responsible for the observed decrease in springtime Antarctic's ozone within the polar vortex, and so over the past couple of years we really do understand where that is coming from.

Some of the detailed processes we do not understand, but being able to say those facts on the floor of the Senate is an important development.

Second, the analysis of data from ground-based Dobson instruments, after allowing for the affects of natural geophysical variability, that are due to the solar cycle and the quasi-biennial oscillation, show measurable decreases from 1969 to 1986 ranging from 5 to 7 percent between 40 and 60 degree north in winter months. That is larger than predicted by any of our photochemical models.

Another statement, and the more recent one, has to do with a rather massive expedition to begin to look at the Arctic. We had some 200 scientists and personnel operating out of Norway, a cooperative effort between NASA, NSF, and NOAA, and our international partners, to try to understand the Arctic ozone issue.

We suspected there might very well be processes there that were analogous to what was happening in the Antarctic. Preliminary results of the recent expedition to Norway have substantially increased our confidence in the scientific understanding of PCS-induced chlorine catalyzing ozone depletion phenomena.

As a result, it is clear that enhancements of chemically active chlorine compounds do occur in both the Arctic and the Antarctic stratosphere and represent additional ozone depletion processes that are not included in the stratospheric ozone assessment models that were used as the basis for the Montreal protocol.

While no unequivocal signature of photochemical loss of Arctic ozone was identified before the end of this particular mission that ended last week. We are continuing to monitor, by the satellite systems, a considerable portion of the atmosphere in the Arctic region. The data tell us that the Arctic is primed for ozone destruction because of the enhancement of ozone-destroying chemicals, chlorine contained in these chemicals.

We can now say these things and this is part of the idea of getting the information out in parallel as soon as we have enough confidence to make these kinds of statements. They are not totally encompassing, and maybe from your perspective you might wish we could be more definitive. We are prepared to go as far as is physically possible to give you the facts as we know them.

Senator STEVENS. I am delighted that you are doing that. And, Mr. Chairman, if I could just finish here?

The CHAIRMAN. The Secretary also wanted to comment.

Mr. BERNTHAL. Yes, I just wanted to make a general comment, Senator Stevens, on the question of scientific certainty.

Senator Gore went through a long list of what really are serious uncertainties in this whole process. That list is one that is worrisome, as an article, again in the New York Times pointed out, not

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so long ago, because, in fact, the question arises whether there might not be a point at which many natural processes increased the speed of global warming rather than decreased the speed of that effect.

But I must say that I spent 20 or 25 years of my life as a physicist in basic research and the complexities of this problem are extraordinary.

The list that Senator Gore went through and the uncertainties there indicates the complexities of the problem. The subject of phytoplankton, for example, has come up.

And I do not intend to cite this as tested, peer-reviewed scientific opinion, but at least one scientist, not so long ago, expressed the view that a few percent change—I think were the numbers but whatever it is, 5 percent, 10 percent change—in phytoplankton could mask the entire warming effect, because of the fact that they are a large consumer and sink of CO_2.

On the other hand, with my responsibilities for oceans, I ask the question of what we are doing to the high seas, not just to the coastal areas, but to the high seas now, when it comes to the pollution problems we are already seeing along our coastlines. And whether we might not be affecting, unwittingly, that phytoplankton cycle.

Maybe the best way to characterize the state of scientific certainty and I will presume to do that—I am sure you will get many opinions—is, as follows: In the case of the Montreal Protocol, and the Ozone Agreement, there was a high degree of scientific consensus on what was, in fact, a much simpler problem in many respects. Lord knows it has its own complexities. But the problem generally is much simpler than the global climate warming or the global warming problem.

I do not know how you would characterize that consensus. I might say 90 percent consensus or something like that. It is fair to say that that degree of consensus does not exist today in the global warming area. Nevertheless, that does not change the fact that even though the timing, the magnitude, and the exact regional climate effects are uncertain—and those are the three areas of considerable uncertainty—the fundamentals seem to be agreed to. And that is that the—and there I think that we do have a high degree of consensus—that we are accumulating greenhouse gases and other things being equal—and I stress that point, other things being equal—that is going to lead to a warming of the planet.

So, I wanted to try and give some sense of where the line of uncertainty can be drawn here. And I realize it is not very satisfying but that is where we are today, in my judgment.

Senator STEVENS. Well, Mr. Chairman, I am pleased to hear that and want you to know that I think all of us support what you are trying to do.

If you recall, in the Soviet Union last year, they had the coldest winter that they have had in years. If you have been reading the papers and watching television lately, you realize that Alaska has just experienced the worst winter in 100 years.

And, so, it is sort of hard for us to contemplate global warming. And, yet, on the other hand, I think the evidence is conclusive that

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there is something going on as far as the ozone is concerned that we ought to understand better.

I hate to see people, as I say, genuflect and react and say that cutting trees with reforestation is the same as deforestation in Brazil, so let us stop all cutting trees until we know something.

And that is why I think it is important for us to have a group like this working and giving us their conclusions as quickly as you can reach conclusions, and, to give us some options too.

If you all tell us that cutting trees in Alaska is bad for the world, we will stop cutting trees. But we do not want to stop cutting trees because someone fears about what is going on in the world.

That is our problem. And I think we need these answers.

Thank you.

The CHAIRMAN. Senator Danforth?

Senator DANFORTH. Mr. Chairman, thank you, very much.

I, too, congratulate you on moving so quickly with this important legislation.

Gentlemen, at the time of the drought last summer, in the midwest, there was some speculation that this was the greenhouse effect in action. More recently, I have seen articles saying that no, it is not the greenhouse effect. It has to do with the water in the Pacific Ocean.

Do you have a view as to whether global warming and the greenhouse effect have already been felt in the midwest?

Mr. BERNTHAL. Well, I will give you an opinion. I do not want to represent this as the last word in the science, Senator Danforth.

I think it is just as dangerous to draw conclusions from one year of drought in the midwest—and I grew up in Nebraska, so I know a little bit about drought in the midwest, and the 1950's were not good years out there—it is just as dangerous to draw conclusions based on one year, or three years, or five years drought in the midwest, as it is from the New York Times article that apparently shows that there has been no warming in the continental U.S. over the last 100 years.

We have to keep our eye on the ball, because it is the long-term effect and the commitment that we apparently are undergoing to long-term warming that matters here. In my own judgment, the drought in the midwest cannot be shown to be related in a cause and effect way to global warming. There is a probability relationship, but probabilities are not cause and effect.

Senator DANFORTH. What does that mean there is a probability relationship?

Mr. BERNTHAL. The assumption is that if global warming occurs, if it is occurring, you will see increased drought frequency in the continental areas of the U.S., the Soviet Union and elsewhere. And that you will see substantially more warming at the higher latitudes—interestingly enough, in view of what happened in Alaska this year—at the higher latitudes than in the equatorial regions.

So, that is the understanding that I have of the global circulation models. So, as I say, the probability, I think, increases as the planet warms, so we are told, that you would experience that kind of phenomenon in the midwest.

This particular case, maybe I will turn to Bob Corell at this point.

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Dr. CORELL. The ability of our computer models to resolve the annual process of climate, just is not there. The time steps are just too large. We cannot predict from our models those kinds of behaviors.

We can predict over decades or over longer periods of time, with increased reliability. We expect to gain these understandings in the future.

I think Secretary Bernthal summarized very well the status of the scientific community. You will find people on both extremes, but I think he gave you precisely the conventional wisdom on this drought last summer.

Senator DANFORTH. Do you think that we are doing—we, being Congress and the Executive Branch—that we are now doing what we should be doing?

Or do you have any advice to us as to what we should be doing that we are not doing now?

Mr. BERNTHAL. Well, I am encouraged by efforts such as we have before us today—the bill that Senator Hollings introduced. The focus there on research is very important. There are a number of other bills that have been introduced that have not been reviewed in detail, at this point, by the Administration.

Someone earlier, in our discussion here today, alluded to jurisdictional tension, I think. And I was not sure whether he was referring to Capitol Hill or to the folks downtown. There, of course, will always be those kinds of vigorous discussions, but if I would make one plea, it would be that we attempt, as best we can, on both sides of the avenue, to try and come up with a well-coordinated process and a sensible, coherent approach to this problem.

That is easy to say, a lot easier to say than to do. But I wanted to pick up on that comment that someone made earlier. I think it is very important that we have coherence in the approach on the Hill and we are trying very hard to develop a coherent approach, and I think, with some success in the Executive Branch.

Senator DANFORTH. Is the appointment of a science adviser to the President an important component in the development of a coherent approach?

Mr. BERNTHAL. Yes, sir.

Dr. CORELL. Yes, I would very much agree with that. This Committee on Earth Sciences was created by the President's Science Adviser about a year and a half ago.

The Committee works within the FCCSET structure, and a strong science advising process would clearly enhance the effort. We have benefited already and we look forward to that appointment.

Senator DANFORTH. But it has not yet been made, right?

Dr. CORELL. To the best of my knowledge, it has not.

Senator DANFORTH. Thank you, Mr. Chairman.

The CHAIRMAN. Senator Pressler?

Senator PRESSLER. Mr. Chairman, I think all my questions have been asked. I do have a statement for the record which I wish to submit. I have been over at the Banking Committee this morning trying to figure out how we are going to come up with $30 billion.

The CHAIRMAN. Senator Pressler, your statement will be included.

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Senator PRESSLER. Mr. Chairman, I have a particular interest in this whole subject, and I have said this before, because of the Earth Resources Observation System, the data center, in my home state of South Dakota.

It archives and distributes land-remote sensing data and it has been doing it since 1973. It will play a key role in the warming of the earth research, weather research and what is occurring. It is now the home of the National Satellite Land-Remote Sensing Data Archive.

So, and I include that as part of my statement, I am pleased to be an original co-sponsor of the National Global Change Research Act. I have some questions for the record, for this panel. Most of them have been covered, so I will not take the Committee's time.

The CHAIRMAN. I thank you, Senator.

Senator Gore?

Senator GORE. Mr. Chairman, I will be brief, because I want to hear your friend and mine, Joe Riley, and others on the next panel.

On the question of CFC's, Mr. Secretary, CFC's are responsible for probably 15 to 20 percent of the global warming phenomenon, would you agree with that?

Mr. BERNTHAL. Yes, that is correct, as I understand it.

Senator GORE. All right, now, CFC's are responsible for probably 90 percent of the destruction of the stratospheric ozone layer, correct?

Mr. BERNTHAL. I believe that is correct.

Senator GORE. The other 10 percent being due to bromides, would you say?

Mr. BERNTHAL. That is a good number.

Senator GORE. All right.

As we prepare our position for the upcoming conference, we had testimony here before this Committee last year, and will have the Arctic Research Team tomorrow. The testimony last year indicated that just to stabilize the rate of damage being done by CFC's, we would have to reduce worldwide production by 85 percent. Do you agree with that, Mr. Bernthal?

That is the EPA's number.

Mr. BERNTHAL. Yes, I believe that is correct.

Senator GORE. Now, under the Protocol, as it now exists, it is called a 50 percent reduction, but there will be an increased production volume until the turn of the century, then a decrease. So, compared to current worldwide production, there will be a decrease of 35 percent, correct?

Mr. BERNTHAL. That is the estimate that I have heard, yes.

Senator GORE. Okay, so under the current agreement, we will see the destruction of the ozone layer and the contribution to global warming from CFC's, not only continue but dramatically increase year-by-year, correct?

Mr. BERNTHAL. If current trends are indicative, that is what you would expect, I believe.

Senator GORE. Now, where bromides are concerned, the damage they do is the square of their concentration, correct?

Mr. BERNTHAL. You have got me on that one.

Dr. CORELL. It is my understanding that is correct.

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Senator GORE. And so as bromides double in concentration, we will see an increase of 400 percent in the damage done by those particular chemicals, under the Protocol that we have agreed to. By the turn of the century, they will double in volume. The damage they do is the square of their volume. Thus, there will be a four-fold increase in the damage done by bromide under the current agreement, would you agree?

Dr. CORELL. But that is a small part, as you know.

Senator GORE. That is 10 percent and there would only be a doubling of the damage done by CFC's, correct?

Dr. CORELL. That is correct.

Senator GORE. Well, can you tell me, can you tell this Committee any reason for concluding that it is anything other than utterly insane for the United States not to push as vigorously as possible for further sharp cuts in the production of these chemicals?

Mr. BERNTHAL. Well, Senator Gore, you asked me that question once before. And——

Senator GORE. That was a private gathering.

I want you to say it publicly.

Mr. BERNTHAL. And my view is that clearly there is a sense of urgency that we are seeing from the latest results from the Arctic.

As Assistant Secretary of State, I am not going to get out in front of Dr. Watson, Dr. Albritton, and the scientific community in reaching a conclusion based on scientific findings that are just now being finalized and will soon be presented, I am sure, in a preliminary way in London.

Senator GORE. Oh, now, now, wait a minute. If I could interrupt because time is so limited.

I am talking about just now. I am talking about the dramatic increase in the damage done. Dr. Watson has already said that in his view it is utterly insane not to have much deeper cuts based upon the findings that existed before the Arctic mission.

Do you agree that even before we got the results from the Arctic mission that it would have been fair for this Committee to conclude that it is utterly insane not to push for much deeper cuts in CFC production?

Mr. BERNTHAL. I expect that you will see a responsible and, I must say, aggressive policy develop on the part of this Administration prior to the meeting in London, and certainly prior to what will be the scheduled reappraisal of the Montreal Protocol in the spring of 1990.

Is there need to move next summer or next fall, before 1990? Perhaps that is one of the things that we need to consider very carefully and, in fact, is now being considered in the inter-agency process.

I simply do not have, for you today, the position that we will officially take at the meeting in London.

Senator GORE. Well, I look forward to joining you as part of that delegation. A lot of countries, China among them, right now are in the process of purchasing industrial equipment that will extend the use of these chemicals well into the next century, as developing nations aspire to higher standards and associate those standards with greater use of these chemicals.

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Just in conclusion, because the yellow light is on and we need to move on, I have introduced legislation that would ban the production of these chemicals in the United States and the importation of these chemicals into the United States, within a five-year period.

I spoke yesterday to the head of the United Nations Environmental Program who said, that, in his view, that would be an extremely positive step, constituting leadership by the United States.

I would note, just by way of a summary statement, that while the two of you are doing a great job, there is a disconnect between the statements that Secretary Baker and you have made, and the U.S. presentation to the response group which disappointed the other countries involved there, with its timidity.

In addition, the recommendation to reduce our funding of the United Nations Environmental Program and other steps minimizing the certainty which exists in the scientific community and calling for more study before anything is done, such as tending to send a contradictory message.

I would hope, as time goes on, we can quickly change that.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

I have deliberately been comprehensive with these two witnesses. You two have been a wonderful help to the Committee and we appreciate it very much.

Thank you, very, very much.

Mr. BERNTHAL. Thank you.

The CHAIRMAN. Our second panel will look at assessing and responding to global change. We will ask them to please come forward.

[Pause.]

The CHAIRMAN. The committee welcomes the distinguished mayor from my home town, the City of Charleston, and past president of our National Municipal Association, the Hon. Joseph P. Riley; Dr. Mark Drabenstott, Vice President and economist at the Federal Reserve in Kansas City; Mr. Thomas Lambrix of the National Association of Manufacturers; and Dr. William C. Clark of the Kennedy School.

Gentlemen, you can see we want to hear from each of you and we want to be able to ask at least a few questions. I would ask, if you do not mind, that we take all of your statements which we have received here at the committee. Under the rules, we will include them in the record in their entirety and ask you to summarize them so that we will have time for everyone here this morning. Mayor Riley, we welcome you.

STATEMENT OF JOSEPH P. RILEY, MAYOR, CHARLESTON, SC

Mr. RILEY. Thank you very much. Mr. Chairman and members of the committee, I am very pleased to have the opportunity to represent the City of Charleston and hopefully all localities in our country.

Several years ago in speaking to a senate committee about our concern about the loss of federal support for programs, I quoted someone who said that America is an interesting nation. We have

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great wealth at the national level, great poverty at the local level, and as luck would have it everybody lives at the local level.

Well, the greenhouse effect in the global or warming trend is a world-wide problem, but as luck would have it all of the impacts will be felt at the local level because that is where our human beings live.

I wish to commend you, Senator Hollings, and the members of this committee who have co-sponsored S. 169. It is urgently needed. We have no time to waste.

I will speak briefly and specifically about Charleston as an example of some of the effects of the greenhouse effect. Charleston is a coastal city. Its old peninsula has on it about a third of its buildings built at or near mean sea level.

Our increasingly populated sea and barrier islands also have a lot of its land at or near mean sea level. Our metropolitan area of a half a million people, most of those live on land that is below 10 feet mean sea level. We have a tidal range of from 5 to 8 feet. We now have many areas that are subject to flooding just from normal spring and fall tides.

Our economy is important to our nation. We have the third largest naval base in our country. We have one of the fastest growing and largest container ports in the United States.

Mayor's jobs are pragmatic ones. We see government at the sidewalk level. Some of the practical effects of a three to five foot rise in sea level over the next 100 years in my city would be as follows: first of all we would see a substantial portion of our city subject to inundation.

This chart, which may not be too easy for you to see from there, but the blue and green area of the old peninsula city of which both of you are familiar, that would be subject to inundation if there was a 5-foot rise in mean sea level just with the normal movement of the tide.

About 20 percent of the peninsula—interestingly enough, where I live, houses that Senator Hollings has lived, where I was born and where I grew up—all would be without protection under water. We can handle that at tremendous cost to the city by raising our sea walls around it enclosing with a system of sophisticated flap gates all of the outfall drainage systems.

Our drainage system is partially 100 years old or more. We are now beginning $130 million drainage master plan improvement. It might not sound like a lot of money, but our annual operating budget is $40 million, or that would be the equivalent of a $3 trillion effort by the national government.

One of the things we are going to do to plan for the greenhouse effect is in the peninsula city have a series of pump stations where our warm water surge will be pumped against the tide, because most of our outfalls now are below mean high water, and so if we have a storm and the tide is anything other than almost low, the water cannot flow up.

These are very costly. One in a section in our city will be about a $4.5 million project, Calhoun and East Bay Street, just to collect the water and have the capability of forcing it out of our system. They are a very expensive undertaking.

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We will have to modify many of our buildings. All of our hospitals have the emergency generating plants on the first floor. They will all have to be raised, and countless other examples of major reconstruction will have to be undertaken, and undertaken soon.

Our bridges are built for ships to clear at the current sea level. The oldest, Grace Memorial Bridge, some of our ships have a two foot clearance. Obviously, if sea level is three to five feet higher something has to give. The bridges, of course, will have to be rebuilt.

The loss of marshland is particularly important. Our marsh grasses grow at two to three inches above mean sea level. The rapid projected increase in the sea level will not give it enough time for normal sedimentation to be added to the marsh area and allow it to grow.

Now, marshes do several things. First of all, they filter our storm water, collecting impurities and keeping them from going into the harbor. Secondly, they are an extremely important part of our marine food chain. The loss of our marshes means the loss of our shrimp crop. The loss in breeding grounds for a lot of the marine life which is important environmentally and very important economically.

Also, our fresh water wetlands, with the infiltration of salt water they become salt water, not fresh water, and their ability to filter fresh water and to purify it for our groundwater systems will be increasingly lost.

Then we have the problem of water infiltration of old landfills, many of which contain solid waste, built and used and dumped many years ago, never with any thought of rising tide. They will have to be either removed or protected so that the rise in water does not further pollute our harbor and our streams.

Basic infrastructure, our streets and our sidewalk systems, will all have to be rebuilt. The rising tide causes a deterioration to them, very labor intensive, very expensive for our city.

The salinity of our rivers will change as salt water intrusion moves up our rivers. This has a very negative affect on industry. It is currently utilizing the fresh water available to it, and other measures will have to be taken.

Luckily, a good bit of our fresh water supply comes from the Edisto River through a 30 mile tunnel. That will be okay, but our secondary source, which is from the upper reaches of the Cooper River with the global warming trend and the salt water intrusion, very costly steps will have to be taken to protect that source of fresh water.

The barrier islands are very important to our economy, increasingly populated. It was said that if Hurricane Gilbert had hit the Charleston area last year at high tide, 50 percent of the building stock on our barrier islands would have been lost. Add three to five feet to the heightened sea level to that and we have a major devastation capable on our sea islands.

Even without the hurricanes, the erosion, the continued rising of the sea level and the erosion of the dunes and the erosion of the islands create major problems. Our access to the sea islands, are all on low-lying causeways. They will all have to be rebuilt. Our bridges will have to be reconstructed.

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More electricity will be needed as the area becomes warmer, creating geometrically the problem alluded to by Senator Gore earlier with the chemicals but in a different way. More electricity, more power plants, unless we find something other than fossil fuels, more CO_2 being put into the atmosphere.

Our vegetation changes, and it may seem like a little matter, but as it gradually changes our ditch systems which are used in our suburban areas to help drain and make sure they do not have flooding problems, we depend upon the cold weather and the dry periods, the vegetation is there to clean them up.

Increasingly as those times are limited, we have to devise new methods for that kind of a drainage system and maybe somewhat lightly, but very importantly, our insects will become more prolific and larger.

What do we need? We need the federal government to develop with a Manhattan project sense of urgency the best projections and baseline data possible. We must give the problem of the greenhouse effect full credibility. Move it from the condition of interesting and contested magazine articles to the basis for accepted data from which a cogent national policy can be developed, and be developed immediately.

Secondly, we must assist local government in planning to assist as they begin to deal with the problems of the greenhouse effect. Long-range planning at the local level is very difficult. Twenty-year planning is extremely difficult.

It is hard for political leaders at the local level to plan beyond their terms of office and beyond their administration, unheard of to plan beyond our lives and beyond the lives of our children, but we must begin a 100 and 200 year approach to planning.

Also in our metropolitan area we have 44 different governments. That is not unusual in our country. The federal government must assist in funding and support regional planning efforts to deal with the problem.

The Environmental Protection Agency should assist in funding capital projects that are very capital-intensive to help us deal with the problems of the greenhouse effect.

I would also suggest that pilot projects—communities on both coasts, our rivers, the Great Lakes, the plains—be selected to early on begin with very long-range strategic planning to show other communities what can and what must be done.

More broadly and locally this year, in my state of city address I announced that we would appoint an environmental awareness committee for our city, based on the simple notion that we are citizens of this planet and we must make sure that we are doing everything in Charleston to be better stewards of the planet Earth, from recycling to using recycling material, encouraging mass transit, and if I may add parenthetically, the last thing our national government should consider cutting is funding for mass transit when we must increasingly encourage people to use mass transit when they do not have to use their automobiles.

Our zoning ordinance is one example in terms of harbor pollution. We have in our building codes and our zoning ordinances that the driveways should be paved in the suburbs. We realize now that the collection through our storm water drainage system of the oils

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and the greases over decades from automobiles contribute increasingly from a non-point way to the pollution of our very delicate estuaries.

Why not change the building code, remove the requirement for paving, go back to gravel or stone or something, where the water is absorbed? There are hundreds of examples. The point is that we recognize in Charleston that we must move environmentally away from reactive posture, what the EPA or state regulatory agency tells us to do, but have the stewardship responsibility to be out front.

We all make—I also might add, we are in the planning stages of building an aquarium, a very popular thing that is happening around our country, but it is not a trendy tool at all. We see it, and we will make it, the most powerful environmental awareness center any community can have.

We will have the world's only large, saltwater marsh estuary. We will have wetland exhibits, and our goal is to have every citizen who leaves there leave, if you will, with environmental goose bumps and understand that someone saying that you cannot fill wetlands is not governmental interference but protecting the water quality of the people in our community.

Lastly, we all make mistakes. I make mistakes. My goal is to try to correct them as soon as possible. If I might, I would seek to observe that the biggest mistake of the last eight to ten years may not have been the huge federal deficit that has been created for us and our grandchildren to pay off. Rather, it was the backing away from a heretofore vigorous bipartisan environmental movement. We have lost much ground, and we have to catch up.

This century, which is coming to a close, for the first half dealt for the first time in our civilized experience with the threat of world wars, conflicts on different continents occurring at the same time. The second half we dealt with the threat of a nuclear holocaust, the ability to kill millions of people.

But the next century will for the time be a time when we deal with the threat of affecting the life negatively of every citizen that lives on our planet. As climate caused by human actions changes and for the most part changes for the worst, drought, famine, economic changes for the worst, our country must be a leader, and through the leadership of you and the members of this committee and S.169, I know we will be that.

Finally, in closing, there is an old African saying which goes as follows: Treat the earth gently. We did not inherit it from our grandparents but rather we hold it in trust for our grandchildren. Our grandchildren and our great-grandchildren are looking to us right now to see what we do to plan for and to seek to prevent the serious impacts of the greenhouse effect.

[The statement follows:]

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TESTIMONY OF

JOSEPH P. RILEY, JR.

MAYOR OF CHARLESTON, SOUTH CAROLINA

Mr. Chairman, I am honored to have been invited to appear today to provide a local community perspective on problems associated with global environmental changes.

INTRODUCTION

The increasing likelihood that the addition of greenhouse gases to the atmosphere will alter the global climate places a burden on all levels of government to begin planning to cope with the effects of global warming.

These effects could include increasing temperatures, changes in rainfall, rising sea levels, and fundamental changes to agriculture and global ecosystems.

My city of Charleston, South Carolina will be impacted by all of these possible effects, but most severely of all by a rising sea level. I realize that cities cannot prevent global warming, but they can aggravate or mitigate its impacts by their responses to this phenomenon.

We have begun planning to deal with these impacts and I am glad of the opportunity to appear before you today because of the critical role of the federal government, in partnership with local communities, in coping with the impacts of global warming and increased carbon dioxide in the

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CHARLESTON, SOUTH CAROLINA

Charleston, South Carolina is easy to locate; it was settled several hundred years ago at the point where the Ashley and Cooper Rivers meet to form the Atlantic Ocean. Much of the main body of the city is a peninsula which has been built over former marsh areas filled in the 19th and early 20th centuries.

Fully one-third of the buildings on the peninsula are built on sites at or near mean sea level, and the city built a seawall at the southern end of the peninsula nearly one hundred years ago. The metropolitan area has a population of nearly one-half million, encompasses a number of barrier and sea islands, is transgressed by several rivers and is surrounded by expansive marsh areas. Our hills attain elevations approaching 10-15 feet above mean sea level.

The past twenty years have witnessed the rapid suburban development that is now commonplace in our nation's coastal areas. Coupled with that, we are experiencing the extensive redevelopment of the peninsular city. Almost of the development is taking place on our few high ground areas and any available waterfront/marshfront areas. The development ranges from extensive residential all the way through light commercial and heavy industry. In addition, the Charleston area is the homeport for the 3d largest base of the U.S. Navy fleet and we have one of the most active container port

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facilities in the United States.

Our low topographic relief serves to shape our development patterns and our way of life. With an average tidal range of 1.8-2.4 meters, the area is prone to flooding during heavy rainfall, particularly with high tides or strong easterly winds. Indeed, the results of several recent winter storms with their strong flooding and extensive beach erosion have been documented by the national press, including Time magazine.

Living at the junction of several rivers at the ocean's edge means that we are living in a very dynamic environment. Our beaches change rapidly, dramatically; their stability is highly variable. Our salt marshes have declined even as our inner estuarine marshes have accreted. All of this has, of course, been affected by the diversion and re-diversion of one of the principal rivers in our watershed--the Cooper River. And human activity continues to influence the already dynamic nature of our environment.

We strive to be sensitive to the special demands of our dynamic environment. Computer modeling provided by the S.C. Coastal Council and the National Weather Service tells us that most of the region's barrier islands would be completely inundated by a moderately severe hurricane if it were to hit at high tide. And, had hurricane Gilbert chosen to come our direction last year, I am told that we would have lost nearly one-half of our building stock.

As one of the nation's oldest cities, we are faced with

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an aging infrastructure strained by inceasing demands. Our gravity-based stormwater drainage system dates from the 1800's. We have been planning a major upgrade to include installation of a series of pumps; however, our efforts to put together adequate funding is equally strained.

Our wastewater treatment system is a mixed blessing. Fortunately, the treatment facility is located about 16 feet above mean sea level. However, it is based on an aging collection system, and we occasionally experience infiltration of floodwaters into the city's sewer system.

We have planned well for water supply. Our primary supply source originates far inland from one of the few unaltered rivers in our state, albeit distribution is through an aged system. And we have a secondary but increasingly important source of raw water located 30 miles up the Cooper River at the Back River Reservoir. But, the rediversion of the Cooper River has made it mandatory to monitor and manage salinity in the Cooper River and Back River Reservoir for both the city's need and that of the multiple industries located on the Reservoir.

GLOBAL CHANGE

In reading the recent U.S.E.P.A. report on the POTENTIAL EFFECTS OF GLOBAL CLIMATE CHANGE ON THE UNITED STATES, I was impressed by the magnitude of the issues facing us. It seemed to me that while we don't have all the information on the timing and rate of global changes, we certainly have

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enough to be concerned. We have enough to begin to consider the range of impacts in our longer range planning.

Out of that report, I also learned that the scope and range of impacts may be quite great on our southeastern coastal areas. The possibility of rising temperatures has its good and bad news for my area. A longer temperate season may be well received by our coastal farmers and beach goers until they realize that these temperatures translate into a longer growing season for insects and nuisance plants. Everyone will need to pay greater attention to maintenance of our various drainage systems.

I also understand that our important coastal fisheries will suffer from elevated water temperatures and the loss of wetlands associated with the various scenarios of sea level rise. An associated concern is the projected increase in salinity for our coastal and estuarine waters.

In fact, the range of impacts associated with the various scenarios and models for global climate change is both profound and somewhat ominous. I am, of course, most particularly interested in those projected impacts that would have the greatest effect on the Charleston metropolitan area. And it seems that one of the most certain aspects of global climate changes is that which would have the most profound impact on our region, that of sea level rise and its ramifications.

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SEA LEVEL RISE AND CHARLESTON

Increased Flooding

Most of the estimates that I have seen state the probable range of sea level rise as 0.5-2.0 meters by the year 2100. I mentioned earlier that Charleston experiences daily tide changes of more than 1.5 meters, with storm tides occasionally raising water levels more than 3.0 meters above mean sea level.

If a rise of even 1.0 meter is superimposed on our baseline for mean water level, then the height of both normal and storm tides is greatly extended. New areas are exposed to tidal inundation, and it increases the frequency and duration of flooding in presently vulnerable areas. Up to one-half of our region could be exposed to frequent flooding.

Associated impacts are complex. As we already experience flooding of key transportation arteries during major storms, the likelihood of increasing flooding is troubling. Our ability to evacuate barrier islands and other low-lying areas in the face of a major storm event will be reduced. And as we are already overdue for our statistical share of severe hurricanes, the likelihood of more frequent and more severe hurricanes due to atmospheric warming is ominous.

Increased flooding will also enhance the degeneration of our streets, thus requiring yet more maintenance. We are going to need to address the fact that all of the hospitals

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on the peninsula maintain their emergency generators on the ground floor. And that we will need to plan for the flood-proofing of the multiple active and inactive hazardous waste facilities that are located on the peninsula.

An increase in mean sea level may also have profound implication for navigational activities in our area. Some ships currently have only a two-foot clearance at low tide while passing under the old Grace Bridge spanning the Cooper River. Certainly, sea level rise poses a challenge to our naval and port facilities.

And sea level rise immediately complicates our current efforts to plan for and design an extended stormwater system for this low-lying region. We will need to expand our management of stormwater runoff in the future, in a region where stormwater management is already extremely complex and constrained by our environment.

Marsh Destruction

Charleston has been the site of several E.P.A.-sponsored studies on sea level rise, including a recent report focusing specifically on the impacts to wetland areas. This is, no doubt, due in part to our extensive marsh areas and our long history of development.

I understand that in the ideal situation that the normal sedimentary processes of wetlands could keep pace with changing sea levels. However, in the Charleston area, the rediversion of the Cooper River (which formerly also carried

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suspended sediment from the Santee River) will reduce the sediment load and consequently reduce the rate of marsh accretion in the future. As a result, our wetlands will not be able to respond as quickly as the sea level rise, even absent human influences.

Louisiana already loses 100 sq. kilometers of marsh annually to the sea. Although we have no numbers for the Charleston area, it is not improbable that our freshwater wetlands will similarly be impacted by saltwater intrusion.

And increased development often provides the impetus for bulkheads, dikes, and seawalls to protect against invading waters and protect investments. The extensive coastal development in the region could prevent the natural migration of marshes by placing concrete in the path of these retreating marsh areas.

The potential losses of wetlands due to rising sea level are varied and significant. As wetlands provide nature's mechanisms for absorbing and slowly releasing stormwater, our stormwater management problems will be further compounded through wetlands losses. Wetlands also provide a natural mechanism for filtering and purifying water; loss of wetlands may have an adverse impacts on our ambient water quality. And, of course, we are all aware that the loss of our riverine and estuarine wetlands will have a devastating impact on important wildlife and coastal fishery resources.

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Increased Salinity

Among the least detailed of the range of impacts associated with sea level rise is that of increased salinity. Certainly, increased salinity will have adverse impacts on wetlands and coastal fisheries. Yet, in the Charleston area, increased salinity would raise significant concern within our industrial communities.

I previously noted that we are already concerned with the increased salinity of the Cooper River precipitated by the rediversion of the Cooper River. Through rediversion, we addressed the navigation and dredging concerns of the Navy Base and Ports Authority, but we now must carefully monitor and manage the Cooper River flows to prevent saline waters from reaching the Reservoir and the intakes of the heavy industrial facilities located along the upper Cooper River.

The prospect of increased salinity will heighten our need for riverine flow management; it will be an increasing concern to our industries, the U.S. Geological Survey (which currently monitors salinity) and the U.S. Army Corps of Engineers (which regulates the flow).

PLANNING FOR GLOBAL CHANGE

We must begin planning now to deal with the impacts of the effects of global warming in general and sea level rise in particular. Federal involvement is critical because of its financial resources and ability to look at a broad sweep of complex environmental issues.

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Local governments, however, must set their own policy directions to cope with the effects of sea-level rise. Tools available to local governments include zoning ordinances, building codes, and local property tax structures.

To a large extent, fiscal constraints will dictate the responses to sea level rise. Cities will have to take a practical approach in allocating scarce resources.

At the local level, political considerations are important. There are more than 44 local governments and special purpose districts in the Charleston area, and the short tenure of most elected officials makes long-term planning difficult. A major challenge will be in convincing local decisionmakers to think in terms of one-to-two-hundred years, rather than the twenty-year view that most planning adopts.

In Charleston we are involved in two major planning efforts that will help to anticipate and mitigate the effects of sea level rise and other environmental problems.

We have developed a Master Drainage and Floodplain Management Plan that will guide our efforts to improve the management of stormwater runoff. The peninsula's gravity-based drainage system dates back more than 100 years. We will need to seek innovative ways to design the new stormwater system to anticipate the problems caused by higher sea levels.

Secondly, I am appointing an Environmental Awareness Committee to analyze and to make recommendations on what we

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as a government can do to be better stewards of the environment. I hope that this group will be the seed of a long-range planning effort that will prepare for the impacts of global warming and sea level rise. They will be looking at the full panoply of environmental concerns: from non-point pollution to recycling to stormwater management to conservation and to coordinated efforts to solve the problems that are pressing upon us ever more urgently.

More specific efforts include a recycling program that will be operated through our Clean City Commission and neighborhood organizations that will recycle newspapers, glass and aluminum. And we will be looking at appropriate changes to our zoning and building codes, such as allowing placement of shell for driveways instead of the present requirement for paving.

COORDINATION AND COOPERATION

Although there are a number of things that cities can do, the federal government is critical to efforts to plan for the mitigation of the effects of global warming.

I salute you in your effort to bring about a sense of order to the national process of understanding, planning and preparing for global change through the National Global Change Research Actof 1989. I encourage your colleagues to take action on developing a national policy. We need concerted global and national efforts to understand and manage global changs.

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The second is that we believe good science must be the foundation for policy actions. Achieving international consensus on what we know and what we do not know about enhanced global climate change is essential. In order to do so we must identify what new research is needed to better define the problem, to prove or disprove the theories and analyze the impacts.

Third, enhanced global climate change requires global cooperation in its study and possible response strategies. Unilateral actions by the U.S., no matter how well-intentioned, will not be sufficient and could be harmful to achieving solutions if they are implemented without consideration for their social and economic impacts.

As you know, other international organizations such as the intergovernmental panel on climate change are investigating this issue. Business applauds this effort and fully supports the U.S. delegation's leadership role. NAM hopes that the role of the IPCC will culminate in the development of a rigorous scientific foundation upon which to base sound, multilateral policy objectives.

In addition to our concerns about the danger of unilateral actions taken by the United States because of the need to link policy actions world-wide, we must also admit that scientific evidence regarding enhanced global warming is inconclusive.

Therefore, given the uncertainties that exist in our understanding of global climate change, particularly in our ability to accurately predict the magnitude and rate of change, we should be cautious in our approach to taking steps that would be costly in societal and economic terms.

We need to avoid a crisis management approach. Our policy should be to strive to preserve the maximum degree of flexibility, and what we do domestically should complement the efforts of the international community.

Scientific journals, local and national press and the media are now regularly reporting on the global climate phenomenon. It seems new research and often new prophecies add to either new information or to heightened public concern.

Business does not argue that climatic change has occurred over the course of history and that it will continue changing in the future. However, a review of the literature reveals that there are inconsistencies and uncertainties surrounding the possible causes, rate of chance and regional impacts from this issue.

We recognize that policymakers are attempting to grapple with decisions of far-reaching importance in the absence of definitive information. But we believe that an expanded and coordinated research agenda such as outlined in S. 169 is a sound investment to make today to enhance our ability to make better policy choices in the not-so-distant future.

Business planning occurs along a similar track. It is based upon a number of things, including consumer needs, capital costs, and technological and competitiveness considerations. Any long-term planning includes risk assessments. Business would find it imprudent to make significant long-term commitments based upon incomplete and conflicting data.

Let me offer a few comments on S. 169. First of all, as I have already said, we believe the bill's focus on integrated research is the appropriate policy response. A nationally coordinated climate

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rivers and streams, drought, the depletion of underground water supplies, and the fact that a football field of forest is lost every second of every day must be a concern to each of us. Unless individuals, cities, states and nations, wherever they live on our planet, become determined to improve our environment, we are sentencing our grandchildren to living in a world not nearly as nice as the one we occupy now.

The CHAIRMAN. Well, I thank you very much, Mayor Riley. The committee did not make a mistake in getting you up here. You have a comprehensive grasp of this problem, and I would hope that it is shared with other mayors. I thought we would have to have an educational program, Senator Gore, but if the other mayors have half the inkling that you have and knowledge about it, we are well on the road to a joint effort at the local and federal level. Mr. Lambrix.

STATEMENT OF THOMAS G. LAMBRIX, DIRECTOR, GOVERNMENT RELATIONS, PHILLIPS PETROLEUM CO., TESTIFYING ON BEHALF OF THE NATIONAL ASSOCIATION OF MANUFACTURERS

Mr. LAMBRIX. Thank you, Mr. Chairman. My name is Thomas G. Lambrix and I am a director of government relations for Phillips Petroleum Co. I welcome this opportunity to speak on global issues before this distinguished senate panel.

I have been asked to testify on behalf of the National Association of Manufacturers, and while I am officially representing only the views of the NAM there is a broader coalition of industry associations and individual companies that is concurrently coordinating its activities on this issue closely with the NAM. I believe my testimony today is consistent with the views of these business groups as well.

The NAM membership has not yet had the opportunity to thoroughly review the details of S. 169, but I believe the bill has many commendable features. It focuses on the first priority, an integrated mechanism for research on the science and the possible impacts of global climate change. This focus is consistent with the views of business, and we commend Senator Hollings and his colleagues for their interest in and commitment to global climate research.

I would like to briefly outline our stance on the global climate issues generally. There are three central elements to our position. The first is that the NAM and other business organizations believe that enhanced global climate change is a serious issue that could potentially impact both our domestic economic base and the economic and environmental conditions of the world.

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The second is that we believe good science must be the foundation for policy actions. Achieving international consensus on what we know and what we do not know about enhanced global climate change is essential. In order to do so we must identify what new research is needed to better define the problem, to prove or disprove the theories and analyze the impacts.

Third, enhanced global climate change requires global cooperation in its study and possible response strategies. Unilateral actions by the U.S., no matter how well-intentioned, will not be sufficient and could be harmful to achieving solutions if they are implemented without consideration for their social and economic impacts.

As you know, other international organizations such as the intergovernmental panel on climate change are investigating this issue. Business applauds this effort and fully supports the U.S. delegation's leadership role. NAM hopes that the role of the IPCC will culminate in the development of a rigorous scientific foundation upon which to base sound, multilateral policy objectives.

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We need to avoid a crisis management approach. Our policy should be to strive to preserve the maximum degree of flexibility, and what we do domestically should complement the efforts of the international community.

Scientific journals, local and national press and the media are now regularly reporting on the global climate phenomenon. It seems new research and often new prophecies add to either new information or to heightened public concern.

Business does not argue that climatic change has occurred over the course of history and that it will continue changing in the future. However, a review of the literature reveals that there are inconsistencies and uncertainties surrounding the possible causes, rate of chance and regional impacts from this issue.

We recognize that policymakers are attempting to grapple with decisions of far-reaching importance in the absence of definitive information. But we believe that an expanded and coordinated research agenda such as outlined in S. 169 is a sound investment to make today to enhance our ability to make better policy choices in the not-so-distant future.

Business planning occurs along a similar track. It is based upon a number of things, including consumer needs, capital costs, and technological and competitiveness considerations. Any long-term planning includes risk assessments. Business would find it imprudent to make significant long-term commitments based upon incomplete and conflicting data.

Let me offer a few comments on S. 169. First of all, as I have already said, we believe the bill's focus on integrated research is the appropriate policy response. A nationally coordinated climate

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research program is essential, and the NAM is especially pleased that S. 169 is based upon existing federal programs.

The NAM is also pleased to see that an integrated research program involving various federal agencies would be coordinated through a federal council, and that the council will work with the Office of Management and Budget in determining annual budget levels for the research agenda.

My written statement details additional comments that we believe can improve the research agenda and the roles of the participating agencies. We have suggested, for example, that major scientific uncertainties, including the role of cloud formations, the oceans, and volcanic activity should be given emphasis in S. 169.

We also believe that the council and the agencies could take more advantage from researchers in the private sector by providing for a more formal role for business scientists. Finally, we have pointed out additional items dealing with monitoring and modeling, where we believe additional emphasis is warranted.

Once again, Mr. Chairman, I and the members of the NAM coalition thank you for the opportunity to share our thoughts on global climate issues and on S. 169. This is the right way to proceed. We encourage moving the scientific studies with all speed, and we are prepared to assist.

Thank you.

[The statement follows:]

STATEMENT OF THOMAS G. LAMBRIX, ON BEHALF OF THE NATIONAL ASSOCIATION OF MANUFACTURERS [NAM]

Thank you and good morning. My name is Thomas G. Lambrix and I am director of Government Relations with the Phillips Petroleum Company. I welcome this opportunity to speak on global climate issues before the Senate Commerce, Science, and Transportation Committee. While I am officially representing only the views of the NAM, there is a broader coalition of industry associations and individual companies that is concurrently coordinating activities on this issue closely with the NAM. I believe my testimony today is consistent with the views of these budiness groups as well. Both the NAM and the other business coalition members recognize that global climate issues are somewhat unique and require additional study to understand the issues, their causes and effects, options to address potential climate changes, and the impacts of their possible solutions.

The NAM membership has not yet had the opportunity to thoroughly review the details of S. 169. "The National Global Change Research Act", but I believe the bill has many commendable features. Particularly it focuses on the first priority—an integrated mechanism for research on the science and the possible impacts of global climate change. This focus is consistent with our views and we commend Senator Hollings and his colleagues for their interest in and commitment to global climate research. I will address some additional comments on the bill later. But your invitation to testify also asked that we provide you with a business community perspective on global climate change generally and what we in business currently believe should be the major policy directions to be pursued. I'd like to briefly offer some comments on this first.

There are three central elements to our position on this issue. The first is that the NAM and other business organizations believe that enhanced global climate change is potentially a serious issue that could potentially impact both our domestic economic base and the economic and environmental conditions of the world.

The second is that we believe good science must be the foundation for policy actions. Achieving international consensus on what we know and what we don't know about 'enhanced' global climate change is essential. In order to do so we must identify what new research is needed to better define the problem, to prove or disprove the theories, and analyze the impacts. This should be our first priority.

The third is that enhanced global climate change is a global issue, requiring global cooperation in its study and possible response strategies. Unilateral actions

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by the U.S. no matter how well intentioned, will not be sufficient and could be harmful to achieving solutions, if they are implemented without consideration for their social and economic impacts. Just as we continue to be concerned with the ability of our planet to adapt to climate change, we must be also concerned with shocks to our domestic and global economies. Precipitous changes in energy supply and use, for example, could cause economic and cultural jolts to all nations.

Recently the NAM board of directors approved a global climate issues policy which I believe embodies these elements. The policy states:

"Society is concerned that gases released naturally and by man's activities might change the climate on a global scale. NAM supports the continuing development of climatic science to address the broad far-reaching questions on global climate changes. Any solution must be implemented multinationally. These solutions should weigh the magnitude of the contribution to the overall climatic alteration against the socio-economic impact of controlling these factors. We urge that international action on global climate change proceed and focus immediately on the causes, effects, and the impacts of possible solutions.

"NAM supports aggressive research into the cause and effect of global climate change, the socio-economic impact of global climate changes and the impacts of proposed control measures. NAM also supports accurate and balanced public education to increase understanding on what is, and is not, known about global climate change."

Clearly, understanding global climate issues is a tremendous challenge for scientists, governments, public policy makers, and business to make certain that global economic development is sustainable and is compatible with the environment.

As you know, the United Nations and other international organizations are addressing both the many scientific uncertainties associated with the enhanced "global warming" hypothesis and the possible responses. The recently formed Intergovernmental Panel on Climate Change (IPCC) of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) is perhaps the leading international body investigating this issue. Business applauds this effort and fully supports the U.S. delegation's leadership role. We are also participating in this effort. Last month, NAM president Alexander B. Trowbridge represented international business in testifying before the response strategies working group of the IPCC. His statement is attached to my written testimony. NAM hopes the IPCC effort will culminate in development of a rigorous scientific foundation upon which to base sound multilateral policy objectives.

In addition to our concerns about the danger of unilateral actions taken by the United States because of the need to link policy actions worldwide, we must also admit that scientific evidence regarding enhanced global warming is inconclusive. Therefore, given the uncertainties that exist in our understanding of global climate change, particularly in our ability to accurately predict the magnitude and rate of change, we should be cautious in our approach to taking steps that would be costly in societal and economic terms. Unilateral actions may prove ineffective as a response to the issue. We need to avoid a crisis management approach. Our policy should be to strive to preserve the maximum degree of flexibility, and what we do domestically should complement the efforts of the international community.

We do not argue with the notion that climatic change has occurred over the course of history and that it will continue changing in the future. Some changes appear to have occurred due to long-term geophysical factors, while other shorter-term climate changes result because of natural events such as volcanic eruptions and other disturbances, like El Nino. We do not believe we can do much to prevent these events.

That the "greenhouse effect" is real is also not an issue. Without the greenhouse effect, the surface temperature of the Earth would be about 60 degrees fahrenheit cooler than today. There is also widespread scientific agreement that those gases in our atmosphere which contribute to the effect (primarily CO_2, CH_4, NO_2, CFCs, and ozone) have been increasing in concentration since pre-industrial times. Further some scientists say there may be a linkage between this increase and speculation that the Earth's average temperature is increasing.

Finally, there is evidence that greenhouse gas emissions, notably from man's activities, are likely to increase and this raises concerns about potential severe shocks to climatic equilibrium with resulting ecological, societal and economic damage on a tremendous scale. What the nations of the world are concerned with, therefore, is the relationship between climate and man-made changes in composition of the Earth's atmosphere. There are many complex processes underway at the Earth's surface and in our atmosphere that we believe prevent us from drawing a simple connection between variations in the Earth's temperature and man-made changes

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in the emissions of greenhouse gases. For example, the balance between incoming and outgoing radiation is also impacted by concentration of atmospheric dust particles and by volume and concentration of cloud and ice cover and vegetation. Moreover, scientists do not understand sufficiently the interactions between the carbon cycle, feedback mechanisms such as cloud formation and the role of the oceans as a heat and CO_2 sink.

Scientific journals, local and national press, and the media are regularly reporting on the global climate phenomenon. It seems new research and often new prophecies add to either new information or heighten public concern. However, it is clear to me that even a casual review of the literature reveals the inconsistencies and uncertainties surrounding this issue. I'm sure the committee members are aware of these problems—whether it be the inability of our super computers to provide accurate climatic projections on a regional scale, the uncertainties behind the conclusions of the official agencies' reports or that new information can refute earlier conclusions which at first appeared justified.

The point is that policy makers must grapple with decisions of far-reaching importance in the absence of definitive information. It is, therefore, essential that if we must ask society to make changes in energy uses and lifestyles, we will have to sustain policies across national boundaries and through changes in the policies of governments. This can only be accomplished if it is preceded by sound science that links theory to fact and clearly demonstrates that such actions are warranted. We believe that an expanded and coordinated research agenda, such as outlined in S. 169, can serve as the basis from which to proceed in the future. Senator Hollings' invitation to testify requested that the NAM identify long-term business planning for U.S. manufacturers as well as planning efforts in terms of global climate changes and sustainable development.

First of all, business should be mindful of the enhanced global climate question as a policy matter due to public interest. Business is taking this issue seriously. At present, however, it is unrealistic to expect industry to make significant long-term commitments based on incomplete and conflicting data. Business planning is based on consumer needs, capital costs, and technological and competitiveness considerations. Any long-term planning includes risk assessments, energy availability and price assumptions, and other prudent considerations. We cannot afford to place the competitiveness of our manufacturing sector in jeopardy based on any speculative theory. Another point to note is that although research planning is usually long-term, typical planning for capital expenditures, even for large companies, is usually 3–5 years.

An excellent example of one of the difficulties businesses have in planning is the use of CFCs in refrigeration. The U.S. Environmental Protection Agency (EPA) is committed to regulate and eliminate CFCs for all refrigeration uses due to stratospheric ozone depletion. However, the Department of Energy calls for CFCs in refrigeration for energy efficiency purposes. To date, CFCs are the most energy efficient substance for refrigeration in residential and commercial refrigerators and freezers. Any movement to CFC substitutes may cause energy efficiency problems. This example illustrates the complexity of the environmental/energy efficiency relationship.

I would like to now offer a few specific comments on S. 169. First of all, as I've already said, we believe this bill's focus on integrated research is the appropriate policy response. We support your objectives and can offer some suggestions at this time:

NAM supports integrated scientific research into all physical, chemical, and biological processes that interact in the Earth's climate system. A nationally coordinated climate research program is essential. NAM hopes that any research program evaluates existing programs as well as deficiencies in the on-going domestic research. We are especially pleased that S. 169 is based on existing domestic research programs and that all future research would be coordinated with U.S. agencies, such as DOE, the National Science Foundation, NASA, the Department of the Interior, the Department of Agriculture, and EPA. Additionally, the NAM believes that an integrated research program involving these agencies should be coordinated through the executive branch with particular emphasis on the Office of Management and Budget. We were pleased to see, for example, that the Government Interagency Committee on Earth Sciences compiled a comprehensive global climate research plan and made these recommendations part of the President's FY 1990 budget.

The already established Federal Coordinating Council is the logical vehicle for this activity, but it should include input from researchers in the private sector, and from academia. If it is totally a Government function, the Council loses the benefit

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of outside thinking. If private and academic input is strictly an advisory function, the Government is not required to consider the advice with the same strength that it might have if the participation were a direct part of the Council's deliberations. We, therefore, believe the private sector input should be codified more strongly than it presently is in S. 169. Also, we believe such research should be coordinated with international scientific organizations.

NAM is concerned that the major unknowns in climate modeling do not seem to get sufficient attention by researchers in current research or in S. 169, in particular, ocean interactions with atmospheric conditions and cloud effects. The specific heat of the ocean is a significant aberration in the climate models used today. S. 169 casually mentions oceanic research but asks the National Science Foundation to do the basic research. Our assessment is that oceanographic research is not one of the central interests of the National Science Foundation. The Department of the Navy collects more physical data on the oceans than any other Federal institution. We would recommend that the oceanographer of the Department of the Navy be included in the Council and be mandated to coordinate the physical data collection on ocean currents and other physical properties.

To emphasize, we believe model research is important. But without structure, it can yield misleading results. Each model must be subjected to sensitivity analysis to determine the most critical input data. These data should then become the primary target for research for the next year. Models can distort informations by error propagation through numerical manipulation. This is inherent in all mathematical calculations. If the data from these models are to be used in policy formulation, they should be challenged to produce the highest quality information. By using sensitivity analysis followed by targeted research, the taxpayer will get the largest return for his research dollar. Clear indications of this process should be included in the annual report to the President of the United States.

Also, while not specifically mentioned in S. 169, methane is four times more active as a greenhouse gas and is the second most abundant greenhouse gas by volume. Atmospheric methane is interchanged at the ocean/atmosphere interface and this important interaction and its subsequent biological fixation deserves considerably more study and emphasis than it had received to date. In fact, since most methane from man-altered sources comes from the agriculture industry, we believe that the Department of Agriculture should be charged with a significant research component on methane generation, movement, and fate as a part of S. 169.

From a purely physical standpoint, upwelling of cooler water has a profound effect on climates. El Nino currents and the lesser known La Nina have profound impact on our climate as last summer proved. If we do not have these currents integrated into climate models, we do little to accurately predict climatic conditions. The National Oceanic and Atmospheric Administration should be mandated to study both the ground observations as well as the satellite and other remote observations relating to upwelling and its impact on the jet stream (consequently weather).

S. 169 gives considerable emphasis on research of man-induced changes to the climate, but equal, if not more, emphasis on natural contributons such as volcanic activity would help to sort out the role man plays on glogal conditions.

Statistical trend analysis to isolate any real changes from the normal variation of natural climatic phenomena is critical to the research on global climate issues. The Federal Government should identify this as a priority for NASA and NOAA.

The other remaining priority reseach area is the effect of clouds. As water vapor increase due to increased temperatures, will the increased cloud cover reduce the incident light reaching the Earth's surface, causing a cooling condition rather than a heating condition? This is a major area of uncertainty and should be addressed as a priority of NASA and NOAA.

NAM also believes that the bill's research agenda should be expanded to (1) include social and economic research related to the domestic and international impact, of proposed solutions and (2) include research on our ability to adapt to climate changes and what additional options might be taken to improve our ability to cope with possible changes.

The role for The Department of State is correctly defined in S. 169 since it will be the major negotiator of any international agreements relating to the global climate issue. This oversight is proper. Research programs must be consistent with other nations to optimize data gathering and information sharing so that other nations may consider their impact on global climate issues and the impact of proposed actions on their nation's social and economic structure.

Finally, the bill states the Department of Energy shall have primary responsibility for research on energy-related carbon dioxide emissions, measurement and research

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to establish a comprehensive national energy policy for reducing carbon dioxide and other trace gas emissions." While the role of CO_2 emissions is potentially an important element of energy policy, we believe that national energy policies should not be based on any single factor independent of other national considerations.

In conclusion, I would like to reiterate any solutions to this global issue should be global in nature. Unilateral actions by the United States could be insufficient and at the same time prove to be significant deterrents to the United States' industrial positioning in international markets. Therefore, we strongly urge focusing on only multinational solutions and a careful study of the cost and environmental impact of any proposed solutions.

Once again, I and the members of the NAM coalition thank you for the opportunity to share our thoughts on global climatic issues and on the proposed amendments to the National Science and Technology Policy Organization and Priorities Act of 1976, as provided for in S. 169. This is the right way to proceed and we encourage moving the scientific studies with all speed and are prepared to assist in this effort. Thank you.

Senator GORE. Thank you very much.

Dr. Mark Drabenstott is Assistant Vice President and Economist for the Federal Reserve Bank of Kansas City. We appreciate you joining us today, Doctor.

STATEMENT OF DR. MARK DRABENSTOTT, ASSISTANT VICE PRESIDENT AND ECONOMIST, FEDERAL RESERVE BANK OF KANSAS CITY, KANSAS CITY, MO

Dr. DRABENSTOTT. Thank you, Senator. My role today is to sort out how weather change will affect agriculture and how it can adjust to such change.

The most severe drought in the past half century struck the United States in 1988. Farmers, agribusinesses and consumers were all affected by the drought. Yet agriculture's inherent ability to adjust to weather disasters diminished the drought's final impact.

The immediate effects of the 1988 drought on U.S. agriculture were less severe than expected. Overall, crop production fell about a fifth from the average of recent years. Because grain stocks were already declining before the drought hit, crop prices increased sharply.

Those higher prices and continued government payments resulted in strong farm income, in fact, matching the record set the previous year. But the uneven pattern of the drought across regions of the country did lead to unusually wide variation in farm finances across producers.

Farm lenders generally were able to take the effects of the drought in stride because most of them had already completed the task of addressing problem loans before the drought hit.

The effect of the drought on agribusinesses was mixed, although a slowdown in livestock production may result in lingering effects for food processors. Consumer food price inflation did increase some due to the drought—to an annual rate of about 6 percent—but the increase was smaller than many early predictions.

As the effects of the 1988 drought attest, weather makes agriculture a risky business. But agriculture has known that for centuries and, over time, agricultural markets have developed a number of sophisticated mechanisms to help the industry adjust to weather change.

Four are particularly important. First, commodity futures markets translate weather developments into meaningful price signals

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and also allow producers to transfer the risks of weather on farm prices to other market participants. Weather information is highly valued in these commodity markets, and many market participants subscribe to private weather information services.

Second, crop insurance is an efficient market tool to roduce the risks of crop loss due to weather. Bad weather normally strikes only parts of the United States with the unaffected regions providing the reserve to operate an insurance fund. Despite the fact that the federal government subsidizes an all-risk crop insurance program, only about a quarter of U.S. crop land was enrolled in 1988.

Third, an integrated world food market provides U.S. and foreign food buyers alternative sources of supply when bad weather strikes a particular producing country. Although the United States is the leading exporter in this market, advancing technology elsewhere in the world provides a sizeable and growing reserve against weather problems here.

And fourth, U.S. agriculture's flexible base of resources provides another strategic reserve against weather change. With 400 million acres of cropland, skilled farmers, and a supporting infrastructure that is second to none, the United States has great capacity to redeploy agricultural resources to minimize the effects of bad weather.

Taken together, futures markets, crop insurance, an integrated world food market and a flexible resource base provide U.S. agriculture with a potent arsenal of tools to manage the risks of weather. It is my view that the United States can best minimize the consequences of future weather change on agriculture by allowing these inherent adjustment mechanisms to function properly.

In light of the 1988 drought and agriculture's ability to adjust to weather shocks, how would U.S. agriculture be affected by continued drought in 1989?

Much of agriculture's adjustment capacity was depleted in 1988, and it is my view that the effects of further drought would be more severe. Grain stocks are much lower now than one year ago. Despite the sharply higher crop prices that further drought would trigger, U.S. farm income probably would decline while consumer food prices would rise more than they did in 1988. The number of farmers experiencing losses almost certainly would increase.

If the United States is entering a period of more volatile weather, public policy makers almost certainly will be asked to respond to agriculture. Government policies should safeguard agriculture's ability to adjust to weather change.

Four public policy issues surrounding agriculture and weather change will be particularly important. First, a clear policy on grain stocks is needed. The United States had large stocks when the 1988 drought hit, but that circumstance was more serendipitous than planned.

Second, free trade in world food markets will be even more important than it is today. If global weather patterns change in the years ahead, the ability of the world food market to send accurate price signals and to move food from food-surplus countries to food-deficit countries will be critical. That conclusion only underscores the importance of a successful outcome in the Uruguay round of GATT negotiations to liberalize agricultural trade.

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Third, the role of the public in providing disaster assistance to agriculture needs to be evaluated, especially in light of current public subsidies to the all-risk crop insurance program.

And finally, the extent to which current farm programs inhibit resource adjustment in agriculture needs to be evaluated. Agriculture has great capacity to redeploy its resource base to offset the effects of weather change. But when government programs override market price signals, that adjustment capacity is diminished.

Thank you, Mr. Chairman.

[The statement follows:]

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STATEMENT OF MARK DRABENSTOTT, ASSISTANT VICE PRESIDENT AND ECONOMIST, FEDERAL RESERVE BANK OF KANSAS CITY, KANSAS CITY, MO

The most severe drought in the past half century struck the United States in 1988. Farmers, agribusinesses, and consumers were all affected by the drought, yet agriculture's inherent ability to adjust to weather disasters diminished the drought's final impact. Several market mechanisms enabled the industry to adjust to the drought.

This testimony suggests that adjustment mechanisms built into the farm economy minimized the impact of the 1988 drought. But much of agriculture's adjustment capacity was depleted in 1988, and the effects of continued drought in 1989 would be more severe. The testimony concludes that government policies should safeguard the industry's ability to adjust to drought and other natural disasters.

These conclusions are developed in four sections. The first section summarizes the effects of the 1988 drought on the farm economy, reviewing the immediate effects of the drought on crop production, farmers, farm lenders, agribusinesses, and consumers. The second section describes the adjustment mechanisms through which agriculture can adjust to weather change. The third section assesses the likely impact of continued drought in 1989. The final section considers public policy implications of future weather change.

The Effects of the 1988 Drought

The most severe drought since 1936 severely affected crop production in many parts of the nation in 1988. The drought's immediate impact on farmers, agribusiness, and consumers, however, was not as great as had been expected. The strong financial performance of the nation's farm sector in recent years left the industry far more resilient to the effects of the drought than it would have been just a few years ago. The drought's effect on agribusiness firms was varied. The main effect of the drought on consumers was a temporary acceleration in the rate of food price inflation. But because farm commodities

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are a relatively small part of retail food costs, the drought's impact on food prices was relatively modest.

Effects on production

A relatively warm, dry spring in 1988 developed into full-fledged drought by mid-summer, severely affecting crop production in many parts of the nation. Overall, crop production fell a fifth from the average of the previous four years. Corn yields were down more than a fourth, soybean yields fell more than a sixth, wheat yields were off about a tenth, and hay and forage production fell about a sixth.

Wide variation in the drought's severity across the nation caused wide regional differences in the drought's effects. For example, most of the nation's wheat losses were sustained in the northern Plains states where yields were down more than half. In contrast, winter wheat yields in the central and southern Plains states equaled the average of recent years.

The drought struck at a time when large crop inventories were already declining under government programs that reduced production and encouraged exports. Last year's drought-shortened production was not sufficient to fully replenish shrinking crop inventories. As a result, crop inventories will be even smaller when the current crop marketing year ends, that is, when harvest of next year's crops begins.

The drought sharply reduced crop inventories that serve as buffer stocks between annual crop production and annual crop usage. At the end of the 1988-89 crop marketing year, wheat inventories are expected to be adequate to fill the nation's total domestic and export needs for only 2.5 months, the lowest inventory level since 1974 and down from a 10-month inventory in 1987. Corn stocks are also expected to fall to about a 2.5-month

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supply, down from an 8-month supply in 1987 and the smallest since the 1984 inventory was cut sharply by the government Payment-in-Kind program. Of these three major U.S. crops, however, soybeans are likely to remain in tightest supply. Soybean stocks are expected to be sufficient to meet the nation's needs for only one month, the tightest inventory since 1973 and down from a 2.5-month supply in 1987.

Effects on Farmers

U.S. farm income was high in 1988 despite the drought. As grain buffer stocks were drawn down, crop prices rose to ration the smaller supplies. The higher crop prices, combined with sales from grain inventories and federal drought relief payments, supported U.S. net cash farm income--the difference between cash receipts and cash expenses--near the record set in 1987. But variation in incomes across producers was unusually large because the drought's effects on 1988 crops was uneven.

Higher prices actually boosted incomes for those producers who experienced only modest reductions in yields or who still held grain stored from previous harvests. For example, many producers in the seven states of the Kansas City Federal Reserve District were included in this fortunate group. Higher crop prices, however, were of much less benefit to producers in the more severely affected regions of the northern Plains and Corn Belt, where crop losses were greater.

Farmers in drought-stricken areas who had not yet fully recovered from the financial adversity experienced in agriculture's recession in the early 1980s were especially vulnerable to additional financial stress. Three consecutive years of record-high farm income, however, lowered the proportion of financially vulnerable commercial farmers in the nation from about one in six in 1985 to about one in nine in 1988. And federal

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drought relief payments expected to total $3.9 billion are partially offsetting the drought's effects on farm incomes in the more severely affected areas. Reflecting generally favorable farm finances in 1988, farmland values continued to increase in most areas of the nation. On balance, financial reserves built up during recent years of strong farm incomes, combined with higher crop prices and federal drought assistance, mitigated the effects of the 1988 drought on most producers.

Effects on farm lenders

After weathering several years of financial adversity in the early 1980s, most farm lenders had the financial stability to withstand the modest increase in problem farm loans that resulted from the drought. The percentage of nonperforming loans at agricultural banks declined in 1987 and 1988, following four consecutive years of increase during the farm recession. Farm bank profitability has improved steadily in recent years, a trend that continued in 1988. According to a recent report issued by the Board of Governors of the Federal Reserve System, the number of financially vulnerable agricultural banks has declined steadily from about 200 at the depths of the farm recession in 1986 to about 50 in mid-1988. In brief, strong farm incomes in recent years improved farmers' ability to repay farm loans. And commercial farm lenders had generally completed the task of addressing problem farm loans before the drought hit.

The Farm Credit System, agriculture's largest lender, was not as well-positioned as agricultural banks to withstand a drought-induced increase in farm loan problems. Problem farm loans composed about a fifth of the FCS loan portfolio when the drought began. The FCS recorded losses totaling more than $4.6 billion from 1985 through 1987, but the FCS did return to profitability in 1988 when farm loan problems proved to be smaller than

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anticipated. On balance, the FCS was somewhat more vulnerable to additional farm loan problems than commercial banks when the drought began. But FCS performance still continued to improve in 1988.

The Farmers' Home Administration encountered greater drought-related farm loan problems than other farm lenders. As the government's lender of last resort, the FmHA acquires high risk farm loans that other lenders are unwilling to accept. Nearly 45 percent of the FmHA farm loan portfolio was delinquent when the drought began. The drought further reduced the probability that many of these troubled loans left over from the farm recession will be repaid.

In sum, most farmers withstood the drought without great financial adversity, diminishing the drought's effects on farm lenders. Most commercial farm lenders had recovered sufficiently from the farm recession to readily absorb the modest increase in farm loan problems brought on by the drought.

Effects on agribusiness

The effects of the drought on agribusinesses were mixed, and the lingering effects of the drought will be felt for several years. The most immediate effect of the drought was on those agribusinesses closest to the farm gate. For example, drought-shortened crop production reduced crop storage, freight, and other handling fees for agricultural cooperatives and grain businesses. But to at least partially offset the shortfall in 1988 crops, fewer acres will be idled in the 1989 government farm program. Larger plantings in 1989 will require larger quantities of crop production inputs and, if weather is normal, will result in a large crop to be transported and processed. Sales by many farm input supply businesses have already begun to surge.

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The drought is also likely to have long-term effects in the agribusiness community. As already noted, an important part of agriculture's adjustment to the drought was a sharp increase in crop prices that has rationed much smaller crop supplies. The higher crop prices translate directly into higher feed costs that, in turn, have reduced livestock feeding profits. Smaller profit margins have likely delayed a long-awaited expansion in the national cattle herd, which is the smallest in nearly three decades. And a rapid expansion in pork production has come to an abrupt halt. Future meat production will almost certainly be somewhat smaller than it would have been in the absence of the drought. Thus, as agriculture continues to adjust to last year's drought, these effects may be felt for some time by food processors.

Effects on consumers

The primary effect of the 1988 drought on consumers was a modest acceleration in the rate of food price inflation. The drought's contribution to food price inflation was modest because raw agricultural commodities, on average, account for less than a third of total retail food costs. More than two-thirds of retail food costs are attributable to processing and marketing costs. Thus, consumer food prices have increased far less than the drought-induced increase in farm commodity prices.

During the last few years, consumer food costs have risen at about the rate of price inflation in the economy as a whole--about 4 percent per year. But the rate of food price increase accelerated in the second half of 1988 to an annual rate of about 6 percent. Food prices will probably continue to increase at this somewhat higher than normal rate through the first half of this year as the impact of the drought continues to filter through the consumer food market. But as farm commodity prices stabilize with a return to normal

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production later this year--the most likely scenario--food price inflation will likely return to a more normal level.

Agriculture's Adjustments to Weather Change

As the effects of the 1988 drought attest, weather makes agriculture a risky business. But this conclusion is not new. Agriculture has been adapting and responding to the vicissitudes of nature for centuries. Over time, agricultural markets have developed sophisticated mechanisms to help them adjust to weather developments. Futures markets, crop insurance, an integrated world market, and U.S. agriculture's flexible resource base are particularly useful. A review of these tools is helpful in assessing how well agriculture can adjust to more volatile weather patterns in the future.

Futures markets

Commodity futures markets are a quick, efficient mechanism for translating weather information into meaningful price signals for agricultural producers and businesses. Futures contracts for major crops, which date to the mid-1800s in the United States, are traded in open auction markets. These markets are especially sensitive to weather change; the prices of crop contracts react almost immediately to new information.

Because weather is a key determinant of commodity prices, accurate, timely weather information is highly valued in the commodity futures markets. Although weather has always been important, advances in telecommunications have brought weather data from a variety of sources directly to the trading floor in recent years. National Weather Service forecasts during the growing season rarely pass without moving crop prices. In fact, weather information is so valuable to commodity markets that many farmers and nearly all commodity brokers subscribe to private weather forecasting services as well. These

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services provide up-to-the-minute meteorological data and alternative forecasts to the National Weather Service.

Futures markets serve two useful roles in helping agriculture adjust to weather developments. First, as fluid, efficient markets, they give producers and other agribusinesses instantaneous signals of how weather developments will affect current and future prices. These price signals are critical to efficient supply and demand decisions in agriculture. In short, prices allocate available supplies and elicit additional supplies in the future. And second, the trading of contracts for future delivery allows producers to transfer weather risks to other market participants that are more willing to accept those risks. Spreading weather-related price risk is one of the most important adjustments producers can make when weather changes dramatically.

Crop insurance

Another market tool to manage weather risk is crop insurance. Crop producers in the United States may insure their crops against single peril natural disaster (primarily hail) with a number of private insurance carriers. Or, they may participate in federally sponsored all-risk crop insurance. In either case, farmers receive protection against weather-related crop loss in exchange for an annual premium.

Crop insurance is an efficient means of managing the risks of weather in production agriculture. In theory at least, crop insurance can be made actuarially sound because the risks can be spread across different regions and crops. That is, bad weather normally strikes only parts of the United States, with the unaffected regions providing the reserve to operate the insurance fund.

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To encourage the use of crop insurance, the federal government sponsors an all-risk crop insurance program, administered in the Department of Agriculture. The government subsidizes roughly a fourth of the total premium as well as paying all administrative expenses and program losses. Despite these incentives, participation remains relatively low. In 1988, for example, only about a quarter of the nation's cropland was enrolled in the all-risk program.

International grain market

A fluid international market for farm products is a vital global adjustment mechanism for managing weather risk. Since the early 1970s, international grain trade has roughly doubled as the number of exporting and importing countries has increased markedly.

The international market provides domestic and foreign buyers of farm products ready access to alternative sources of supply. The United States is the leading exporter in the world food market, supplying 40 percent of the grain and 70 percent of the soybeans traded in world markets the last two years. But rapid advances in agricultural technology in the 1980s throughout the world have added substantially to the world's capacity to produce food. Thus, despite the importance of U.S. exports to the world market, there remains a sizable and growing reserve of food production abroad.

In short, the emergence of a well-developed world food market has made the U.S. and world food supply more secure from weather disruption. Adverse weather in the United States probably means it exports less, and the United States might add substantially to its food imports if weather cuts domestic farm production severely. Conversely, if weather patterns turn for the worse abroad while remaining favorable here, the United

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States could supply large amounts of grain to world markets, just as it did in the early and mid-1970s. Obviously, this view of the world food market only underscores the need to promote free trade in the world food market. World agriculture's ability to adjust to more variable weather will be affected by the success of the Uruguay Round of GATT negotiations in liberalizing agricultural trade.

U.S. agriculture's resource base

U.S. agriculture's tremendous base of resources provides a strategic reserve against weather change. The United States has a crop base totaling about 400 million acres, skilled farmers, leading edge agricultural technology, and a supporting farm infrastructure second to none. As prices change due to weather developments, farm resources shift into production of those products in greatest demand. Most of these supply responses occur from one crop year to another, but others can happen more quickly.

U.S. agriculture's ability to redeploy its resource base in the face of weather change depends critically on accurate price signals. Futures markets, as noted above, are efficient in translating weather information into prices. As it turns out, however, those prices are not the only ones to which producers respond. Federal programs that support farm commodity prices also enter into farm decisions. Recently, farm programs appear to have impeded agriculture's flexibility to adjust to drought.

Distortions in the soybean and oats markets illustrate how farm commodity programs may inadvertently hinder agriculture's ability to adjust to weather shocks. The 1988 drought cut soybean and oat stocks to extremely low levels. The corresponding rise in soybean and oat prices should trigger increased plantings in 1989. But, the program benefits for planting corn are so great that many farmers will resist switching to soybeans

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or oats. The Disaster Relief Act of 1988 did include a provision aimed at freeing up more acreage for soybeans and oats. Even so, current U.S. farm programs still result in fairly rigid crop patterns. That rigidity diminishes agriculture's inherent ability to reallocate its resources to best offset weather change.

Taken together, commodity futures markets, an international market for farm products, and U.S. agriculture's flexible resource base provide a set of market tools that can ease the adjustments that accompany drought or other adverse weather. But these tools work best in managing the consequences of one-year weather disruptions. A sustained period of adverse weather in the United States would obviously create bigger adjustments that, over time, could strain these market mechanisms. If the United States does enter a multiyear period of adverse weather, this will have some serious negative consequences for farmers, agribusiness, and consumers. Clearly, the United States can best minimize those consequences by allowing agriculture's inherent adjustment mechanisms to function properly.

Possible Effects of Continued Drought in 1989

In light of U.S. agriculture's capacity to adjust to weather change, how would it be affected by continued drought in 1989? In brief, agriculture used up much of its capacity to adjust in 1988 and thus is much more vulnerable to negative effects than a year ago. The most pronounced effects of continued drought would be sharply higher crop prices, increased farm financial stress, and higher food prices for consumers.

The lowest U.S. grain stocks since 1980 have already set the stage for sharply higher grain prices if the drought persists. Supplies are small enough that weather-induced cuts in the 1989 crop will be felt quickly and significantly in crop prices. If 1989

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witnesses a drought of equal magnitude as in 1988, it is likely that prices for major crops would climb to record or near-record levels. Large crops elsewhere in the world would limit crop price increases in the United States, but not prevent them.

More farmers would experience losses if the drought persists, and farm income would probably drop sharply. Many crop producers added to their 1988 income by selling grain inventories built up in earlier years, an option that will not be available in 1989. Thus, despite the very high grain prices that would accompany continued drought, smaller crops and depleted inventories would probably mean smaller farm income. The high grain prices would also be a severe blow to the livestock industry, which has contributed significantly to agriculture's recovery in recent years.

Finally, consumers could expect the high crop prices to contribute to higher food prices. With grain stocks so low, continued drought likely would lead to bigger increases in food prices than occurred after the 1988 drought.

Although the possible effects can be outlined, continued drought for U.S. agriculture appears unlikely in 1989. Agricultural records indicate that every year of drought in the United States since 1950 has been followed by a year of rebounding production, and in most cases the increase in production has even led to re-accumulation of grain stocks. These facts appear to be consistent with the current suggestion that U.S. weather is resuming a more normal pattern.

Agriculture and Weather Change: Public Policy Issues

Public policymakers almost certainly will be asked to make some policy responses if agriculture enters a period of more volatile weather. There is a long history of federal response to natural disaster in agriculture. The Disaster Relief Act of 1988 was a swift,

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mprehensive response to the 1988 drought. In light of agriculture's ability to adjust to eather developments through market mechanisms, how should public policy respond to veather change in the future?

The public role in disaster assistance

The role of public policy in responding to natural disaster in agriculture is somewhat unclear. Historically, public policy has placed a safety net under agricultural producers. The question is, how far off the ground should that net be?

Producers can reduce weather risk through crop insurance. But many producers do not insure crops because a past pattern of public disaster assistance leads them to conclude that losses will be covered--at least partially--without incurring insurance premiums. This leaves the public in the dubious position of subsidizing the all-risk crop insurance program and providing disaster assistance. In short, the role of the all-risk crop insurance program needs to be re-examined. A strong case can be made for making that program the sole weather-risk management tool for crop producers. The public already provides a large subsidy to the program, and producers should be encouraged to take advantage of that support.

Grain stocks

Grain stocks are critical in buffering the effects of weather on agriculture. From the time of Joseph, stocks have supported prices in times of surplus and damped prices in times of shortage. Fortunately, the United States had substantial crop stockpiles when the drought of 1988 hit. But that circumstance was more serendipitous than planned. The huge U.S. grain surpluses of the mid-1980s were mostly the by-product of commodity programs whose principal goal was maintaining farmers' incomes.

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If the United States is entering a period of more volatile weather, a clear policy on grain stocks is needed. Three key questions surround this policy. First, how big should U.S. stocks be if weather patterns are becoming more volatile? Second, who should hold the stocks--the government, farmers, or both? And third, how do U.S. grain stocks relate to global reserves? These questions do not have immediate answers, but global weather change would bring them to the fore.

Free trade in world food markets

If global weather patterns change dramatically in the years ahead, a free-flowing world food market will become even more important than it is today. The ability of that market to send accurate price signals and move food from food-surplus countries to food-deficit countries will be critical.

This conclusion only highlights the importance of the Uruguay Round of GATT negotiations. The modest distortions that U.S. farm commodity programs introduce into agricultural production are multiplied many times over in other producing countries, and especially in the European Community and Japan. Removing those distortions worldwide will add considerably to world agriculture's capacity to respond quickly and efficiently to weather changes. Conversely, if subsidies proliferate and trade barriers continue, the costs of weather shocks will be borne more heavily by the affected region. Liberalizing agricultural trade will not only ease the burden on national treasuries, it will also better prepare us for future changes in weather patterns.

Senator GORE. Thank you very much. We certainly appreciate your testimony and, again, we will have questions later.

Our final witness is Mr. William C. Clark, who is a senior research associate at the John F. Kennedy School of Government at Harvard. We appreciate your presence, Mr. Clark. Please proceed.

STATEMENT OF WILLIAM C. CLARK, SENIOR RESEARCH ASSOCIATE, J.F. KENNEDY SCHOOL OF GOVERNMENT, HARVARD UNIVERSITY, CAMBRIDGE, MA

Mr. CLARK. Thank you for the opportunity to be here both on my own behalf and representing the National Academy of Sciences' Committee on Global Change on which I serve.

I have been asked to speak on the challenges of, and obstacles to, developing response strategies for dealing with global change. The central point I would like to make is that we are entering in the late 1980s a period in which the traditional subject matter of international affairs is changing. In the sixties, the focus was on national security issues. Great fights and conflicts arose in both academia

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and government in the seventies as economic competitiveness issues moved their way to join security concerns on center stage.

What we are witnessing now is the emerging of global environmental change as a third partner. The issues of national security interests, economic competitive interests, and environmental sustainability interests are today all significant bargaining and negotiating chips with which national and international policies will be dealing in the nineties and beyond.

Senator GORE. If I could interrupt, just to complete your creating a catholic list of issues, I would add a fourth. The area of human rights and the values of democracy and freedom is the fourth major area of conflict and challenge in which we have engaged. But I agree with the others. Excuse me for interrupting.

Mr. CLARK. I plead nolo.

If we include Mr. Gore's quite proper addition, this view of the international stage was the one sketched out by the Brundtland Commission, (the World Commission on Environment and Development) as it reported out in 1987.

If we take its perspective seriously, which I certainly believe we should, we face four challenges in shaping useful response strategies to that intersection of major interests on the international scene.

The first is one of linkage. These issues of global environmental change we face do not come to us problem by problem. We no longer have the luxury of one group looking at greenhouse issues, another at ozone depletion, a third at deforestation, a fourth at acidification, a fifth at urban smog. These issues are intimately connected by the human activities that cause them. The kinds of responses that we may make to them on both the source and the adaptation side are also intimately connected. Until we can begin designing frameworks for treating those linkages seriously, we are likely to be running in counterproductive directions with our policies and to be providing less than the maximum argument we can in support of some of the steps that need to be taken.

The second challenge is that these issues, while certainly global, are simultaneously local in nature. That is, while all parts of the world are influenced by these major environmental changes.

The precise "faces" that those changes exhibit take are going to be different for different locations, different peoples, and different socioeconomic groups within nations. Until we recognize these different local perspectives on greenhouse issues, global change issues, ozone issues, and such, we risk coming into national and international debates with what will look to all other participants as very narrow self-serving perspectives. We have had some trouble with that already in the greenhouse issues. We need to discover what these problems look like to other actors on the international stage.

The third challenge of course, is one of timing. The point was made earlier of the difficulties in treating issues that are serious but not yet a crisis. We have to begin thinking about policies and strategies on a decadal scale. We need to emphasize learning in which the insistence is not so much on getting our action or our decision exactly right today, but on establishing a track record of getting our decisions sequentially righter as we go along.

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Fourth is the challenge of uncertainty which, of course, has been central to other testimony today. The point I wish to emphasize however, is that the central challenge of uncertainty is not reducing it to zero, but rather the challenge of pursuing simultaneous tracks that invest in research to resolve the resolvable uncertainties at the same time that we adopt policy and action strategies to mitigate the known problems. This parallel approach will and to provide us with insurance, as it has in so many other sectors of activity, against those problems where there is a measurable chance we may be in trouble, but no certainty that we are.

How to move ahead in meeting these challenges?

The scarcest resources is obviously leadership, and I do not need to provide a lecture on that to this forum. On the research side I think S. 169 provides an excellent foundation. It is long range, setting a ten-year horizon which is exactly what we need. It is interdisciplinary and interagency to get us away from our problem-by-problem focus. It is globally oriented, recognizing that the research needs have to be pursued in an international context, both on scientific grounds, but also to have any credibility when we move into policy debates.

On the action side, the situation is one we can be much less sanguine about. Here is where we face some very special challenges that lie within the purview of this committee. The most serious of these, I believe, is how we bring the policy issues posed by global change into an international framework. As several people have mentioned, in Section (e) of the present draft of the bill there are, properly, provisions made for the Secretary of State and the chairman of the Federal Coordinating Council to coordinate their activities as we go into international discussions. But if we treat seriously this new relation between security, economic and environmental issues, we have to ask whether Section (e) goes far enough.

It is not clear to me that in this bill there is any forum created for regularly reviewing the implications of global environmental change for our broader foreign policy objectives or our strategies to ensure economic competitiveness. Without such a forum it is virtually guaranteed that we will continue pursue policies in those areas independently, in ways that turn out to be contradictory and in the long run counterproductive.

The task of shaping such a forum is probably the central policy challenge we face over the next five to eight years in moving towards a way of bringing international environmental issues to an effective center stage position in the international debate. We should certainly treat seriously the President's remark that the "White House effect" will make such forums a central concern for his administration, but we also have to recognize that this is more than a matter of administration. Rather, it is a matter of the character and approach we want our country to display as we enter what could well be the century of global environmental issues. In establishing this approach we are going to need explicit leadership from bodies like the one meeting here today in the Senate. Thank you.

[The statement follows:]

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International policy perspectives on global atmospheric change: Expanding the range of options

William C. Clark

1. The global context of atmospheric change

Questions raised by the changing character of the world atmosphere have been intensely studied over the last decade. Several recent reports, most notably those of the US Global Change program and International Geosphere- Biosphere Program, have summarized the scientific findings of this work[1]. The question remains, So what? What are the practical implications for policy?

The following pages seek to sketch a useful framework for reflecting on how answers to the "So what?" question might look, and on how we might go about getting them. It does not attempt to provide the answers themselves, nor to summarize the answers that others have given.

Some justification for this approach is warranted. Policy makers and people in general have become increasingly impatient with a scientific community that always seems willing to raise possibilities of terrifying things that might go wrong, but never seems willing to commit itself on how seriously the possibilities should be taken, or on what action they require. Why shouldn't we finally attempt a "bottom line" assessment of the policy implications of the global atmospheric change? Can general frameworks of the sort proposed here really provide a more useful approach?

My own response to this challenge is based on four fundamental characteristics that stand out in recent reviews of global atmospheric change[2]:

* Possible causes and effects of atmospheric change are intimately linked to other problems of energy, agriculture, population and environment. The linkages are physical, biological, economic and political. Action taken on problems like stratospheric ozone depletion will reshape the greenhouse question; actions taken on the greenhouse problem will affect other atmospheric issues in turn. The policy implications of global atmospheric change cannot usefully be addressed without accounting for linkages among related problems and their solutions.

* The problems of atmospheric change are simultaneously local and global. For example, all countries of the earth are potentially affected by environmental changes related to the greenhouse effect; no country can do much unilaterally to forestall those changes. The nature, severity and perception

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of greenhouse-related impacts will nonetheless differ greatly among peoples and places. A useful discussion of the policy implications of atmospheric change must reflect these differing local and national perceptions of an intrinsically global phenomenon.

* Finally, uncertainty dominates every aspect of global atmospheric change, from emission rates through environmental consequences to socioeconomic impacts themselves. Assessments that do not address these fundamental uncertainties will be extremely misleading. Useful policy analyses must find ways of characterizing the implications of our incomplete scientific knowledge. They must highlight the impossible and barely possible as well as the most probable impacts of the increasing impacts of human activities on the atmosphere.

"The" problem of global atmospheric change thus has much in common with other grand concerns like "the" population problem or "the" problem of economic development. Such multifaceted, complex problems can be better described as "messes". Experience with messes suggests that any attempt to resolve them will be futile if it presumes the existence of a few key "decisions" or "decision makers"[3]. Like the population and development messes, atmospheric change will have different practical implications for different sectors of the economy, different nations, and different generations. Each of these will make its own interpretation of costs, benefits, uncertainties and suitable responses. Most of whatever social responses do occur will consist of each group's incremental adjustments to its own ongoing activities, taken in the context of its own agenda of other problems and solutions. In such a real world mess of multiple actors and actions, no-one's needs will be served by single "bottom line" assessments that purport to speak for all people and all times.

More useful would be a set of effective tools and approaches that individual nations and interest groups could employ in coping with the practical implications that global atmospheric change may hold for them[4]. Collaborative use of the tools to shape regional or even global responses would be possible, but independent local responses would be facilitated as well. The tools most needed would help to shape incomplete scientific understanding so that it can be critically applied in the construction of appropriate social responses. They would be useful for expanding the conventional menu of possible social responses and for characterizing their respective strengths and limitations. They would provide means of addressing, if not resolving, each of the fundamental characteristics of global atmospheric change listed above. Ideally, the tools could also be used to fashion a commonly accepted, relatively unbiased perspective from which the different interests in the debate over global atmospheric change would better comprehend each others' concerns and preferred actions.

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Several recent studies have begun to construct important components of the set of tool needed for coping with practical implications of global atmospheric change. Despite some gratifying progress, however, the tool kit needed for societies to cope effectively with global environmental change is far from complete. For example, even the best policy analyses and assessments have tended to take their questions from the immediate concerns of natural scientists studying global atmospheric change, and to concentrate on providing answers. But as Thomas Schelling has shown in the most perceptive treatment yet written on social implications of global atmospheric change, this approach leaves many of the most practically relevant questions unformulated and unstudied[5]. Missing are the broader perspectives that could help to locate questions of atmospheric change within the context of related economic trends, political agendas, and environmental problems. It is these contextual issues that will both shape impacts of atmospheric changes on societies, and provide societies with their options for dealing with these impacts. The remainder of this paper attempts to characterize some of the missing perspectives and to provide some of the tools needed for working with them.

2. Linkages in global atmospheric change

As noted above, changes in the global atmosphere are tightly coupled to one another, not only through their physics and chemistry, but also through their common human sources and impacts. A synoptic perspective that emphasizes these linkages is necessary for the development of effective and efficient policies.

One step towards this such a synoptic framework has been developed by Drs. Paul Crutzen of the Max-Planck Institute for chemistry, and Thomas Graedel of AT&T-Bell Laboratories[6]. The approach adopted by Crutzen and Graedel can usefully be viewed as a form of environmental impact assessment[7]. Experience in environmental impact assessment shows the importance of beginning with an explicit statement of valued environmental components, ie. properties of the environment that are thought to be most worthy of attention or protection in a given assessment context[8]. As such, valued environmental components (should) reflect the judgments of the broader political and social communities as well as those of scientific experts. For illustrative purposes here, the valued environmental components identified by Crutzen and Graedel and described in Table 1 will suffice.

environmental impact assessment aims to establish the causal relationships between valued environmental components and potential sources of environmental disturbance. The last decade has brought about major advances in our understanding of the atmosphere, its chemistry and physics, and its interactions with the biosphere[9]. Figure 1 shows the results of Crutzen and Graedel's initial effort to summarize our present knowledge of the relative

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influence of various sources of change on valued components of the atmosphere.

Each cell entry of Figure 1 indicates the relative impact of the specified perturbation source on the specified valued atmospheric component. This can be seen more clearly in terms of the specific example of the impact of coal combustion on the thermal radiation budget (Location 'a' in Figure 1). Obviously, the details of such an assessment can be enormously complicated. Large research programs, scientific monographs, and official reports have focussed on just one or two cells of the matrix (eg. the many works on "energy and climate")[10]. Even these relatively narrow efforts inevitably end up pushing scientific understanding to and beyond its limits. For this reason, some estimate of the relative confidence that the scientific community has in its inevitably incomplete and uncertain assessment is essential. Crutzen and Graedel have therefore included a qualitative expression of relative uncertainty in each of the cell estimates given in Figure 1.

Column assessments: The most useful aspects of the framework developed by Crutzen and Graedel are not their individual cell assessments, but rather the synoptic perspective gained by viewing the relations among those cells. Two dimensions of this synoptic perspective merit special attention. First, consider the "cumulative impact assessment" that comes from looking down any individual column of Figure 1 and noting all of the natural fluctuations and human activities that significantly affect a specific valued atmospheric component. In the case of the thermal radiation budget, the figure summarizes our understanding that while fossil fuel combustion is now the dominant source of anthropogenic climate change, other factors including certain industrial processes, biomass burning, crop production, and changes in the biological activity of natural vegetation and soils all may play a significant role. As several recent reports have emphasized, efforts to understand the likely course and implications of climate change must move beyond a preoccupation with individual chemicals like carbon dioxide, to include a comprehensive appreciation of the multiple sources involved.

Row assessments: The second synoptic dimension of environmental perspective summarized in Figure 1 comes from looking across individual rows. This view shows all of the valued atmospheric components significantly affected by a specific source of natural fluctuations or human perturbation. It is the aspect of the Crutzen and Graedel framework most immediately responsive to the "action" orientation of policy making. The figure shows that policy measures taken to change the source of perturbation to one valued environmental component will almost inevitably affect other environmental components as well. To continue our earlier example, action to reduce coal combustion because of its impact on climate (Location 'a' in Figure 1) could also be expected to have a significant effect on photochemical oxidants, the acidity of precipitation, visibility, materials corrosion, and probably the absorptio-

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of ultraviolet radiation. The extent of the effect would obviously depend on the details of the policy adopted. But one conclusion is inescapable: if we are going to produce useful knowledge for guiding policy choices, a much greater portion of our assessment resources and attention must be put into row assessments of the net impact of major policy options across a wide range of valued environmental components. This is a difficult but not impossible task. A few studies have attempted partial "row assessments", among them the US National Academy of Science's reports on Nuclear and Alternative Energy Systems and on Atmosphere- Biosphere Interactions[11]. The pitfalls and potential revealed through such studies provides a foundation of experience on which the present generation of policy analyses of global atmospheric change can be built.

3. Enriching the range of policy options

The range of possible policy responses that has been explored in the debate over global atmospheric change remains extremely narrow. Most discussions reflect a preoccupation with actions that would reduce the production of pollutants like CO_2 or SO_x through changes in energy policy. Much less attention has been paid to the possibilities for adaptation to changing agricultural conditions, sea level, or other impacts of change in valued atmospheric components. Managerial options to restore damaged systems have been virtually ignored. In other contexts, expanding the range of actively debated options for action has often been one of the most useful roles played by policy analysts[12]. Needed are tools that can systematically survey possible leverage points across the whole sequence of interactions running from human actions through environmental change to social consequences.

A point of departure for constructing such tools is the classic model for environmental impact assessment shown in the upper panel of Figure 2. In this useful caricature of complex reality, human activities like fossil fuel combustion release pollutants and other substances like carbon dioxide. These substances interact with a variety of other environmental constituents and processes. Changes result in one or more valued environmental components like climate. These changes in turn have social consequences through their impacts on important properties like agricultural yield.

As noted above, most thinking on possible policy interventions to this sequence has focussed on its two extremes, ie. on polluting activities and on social consequences. Thomas Schelling, however, has argued that policy responses are in general possible at each stage of the sequence[13]. To help guide the design and assessment of specific policy options, he posed a framework consisting of four potential goals for social response, one corresponding to each stage of the classic assessment model. In a form

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slightly altered to give greater generality, these potential goals are listed in the bottom panel of Figure 2.

Altering production of pollutants changes the possibility of inducing environmental changes in the first place. Such changes might, of course, be beneficial. The framework makes no presumption that less production is better than more. Figure 1 makes clear, however, that changes to reduce the production of emissions from fossil fuels would have beneficial impacts across a wide range of environmental components. Recovering releases of emissions from the environment is another potential solution. It has seen extensive use in combatting problems of acidification, but little as a component of policy responses to the greenhouse problem. Social responses capable of modifying the environment could counteract unwanted changes in valued environmental components, or encourage wanted ones. A long tradition of environmental management, impact mitigation and ecosystem restoration activities reflects efforts to achieve this goal. New efforts in intentional climate modification, long range water transport or reforestation may be called for by emerging global problems. Finally, the goal of adapting to change can be pursued through a wide range of formal policies and informal actions that seek to mitigate the damages and capitalize on the opportunities associated with changing environments.

Space does not permit the detailed consideration here of specific policy options for addressing each of these goals for the management of global atmospheric change. Some of the more obvious possibilities are summarized in Table 2[14]. More generally, however, the national and international policy efforts should be encouraged to undertake systematic and imaginative explorations of the full options framework suggested here.

4. Policy Exercises: Learning to cope with global atmospheric change

This note has focussed on the design of tools that, I have argued, individual nations and interest groups should find useful in coping with the policy implications of global atmospheric change. Clearly, many of the proposed tools have barely been sketched. None are as well developed as they might be. All would benefit from further efforts directed towards their improvement. But with all tools and would-be practical devices, there is a limit to how much improvement can be expected from theoretical studies divorced from actual conditions of use. And no tool has value independent of the skills of its user — skills that can only be learned through long and continuing practice. If the tools and approaches suggested here are to evolve into something of practical value for societies, societies must find ways of putting them to work. Only such exercises in application can produce a realistic feel of how we can best use the tools, of what are their actual strengths and limitations, and of where they can best be improved[15].

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ight such exercis lc 1 What skills would they try to develop?
ild they provide ... to apply and test our incomplete
anding of globa c change and possible policy responses to

d for practice: Practicing with Earth itself obviously has its
ks. Scientists may speak of the human releases of carbon dioxide to
osphere as "a great geophysical experiment", but the results of this
ilar experiment may come in a bit late to be of much use for those
in the test tube. The obvious al ive of practicing on various
tical models of the Earth also to be desired. Any notion
idently predicting the practica of alternative response
wilts under the numbing scale l ... of global atmospheric
, the profound uncertainties tha ... our scientific
anding of it, and its dependenc- ... ly complex and uncertain
ound" changes in the world's en irc and societies. Moreover,
simpler contexts, formal models have generally not been conducive to
e interaction among scientists, politicians, and other people that
e such an important aspect of social learning to cope with the global
aric change.

eful means of practicing how to cope with complex interactions of
ents and societies are badly needed. Considerable attention has
voted to those needs in the program on "Sustainable Development of
sphere" now being carried out by IIASA, the International Institute
lied Systems Analysis's[16]. Following an extensive review and
ion of experience with alternative approaches[17], the IIASA effort has
ed a program of "policy exercises": organized efforts that bring
r policy people, scientists, and technologists to practice writing
histories" of plausible interactions between societies' development
ies and the global environment. The possible relevance of these
e to the design of policy responses for dealing with global
ental change is discussed below.

al exercises and war gaming: Policy exercises are derived from
hes developed in support of political- military strategic planning
the late 1950's and early 1960's[18]. At that time, experience had
hat formal models were inadequate to capture the contingencies, the
ifiable factors, and the contextual richness that seemed central to
in lines of political evolution between the great powers in the period
1965. The models also tended to strengthen rather than relax the
between analysts and practitioners of political and military
y. In attempting to design more useful integrative approaches,
Goldhamer of the Rand Corporation realized that his "problem was
to that confronting historians. He was faced with the task of

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writing a 'future history' to clarify his ideas about the motives and influences affecting the behavior of great powers, their leaders, and others in the real political world."[19]

The method devised by Goldhamer and his colleagues to write these future histories was dubbed "political gaming". Teams of human (as opposed to computer) participants were confronted with generally realistic problem scenarios and required to work through responses both to the scenario and to the moves made by other teams. The role of "Nature", which determines the impact on conditions of play resulting from the moves of the teams, the injection of unexpected events, the introduction of constraints on allowable responses, and so on, was played by the control team responsible for organizing the exercise.

Brewer has described four "difficult questions that eluded or exceed the capacity of alternative analytic tools" that were explored by the original political exercises[20]. These questions sufficiently resemble those that confront us in learning to cope with global atmospheric change to warrant quoting here:

* What political options could be imagined in light of the conflict situations portrayed? What likely consequences would each have?

* Could political inventiveness be fostered by having those actually responsible assume their roles in a controlled, gamed environment? Would the quality of political ideas stimulated be as good or better than those obtained conventionally?

* Could the game identify particularly important, but poorly understood, topics or questions for further study and resolution? What discoveries flow from this type of analysis that do not from others?

* Could the game sensitize responsible officials to make potential decisions more realistic, especially with respect to likely political and policy consequences?

Future histories of global atmospheric change: Experience with political gaming indicated that each of the preceding questions could be given an answer of "yes, but only under favorable conditions"[21]. The same experience led to several additional conclusions suggesting that the political exercises might serve as a basis for designing policy exercises to practice social responses to the problems of global environmental change. Elsewhere, I have dealt at some length with these potential linkages between exercises in political and environmental policy[22]. Some of the most important are summarized below:

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* The politic[illegible] s[illegible] fi[illegible] to per[illegible] better than alternative proaches in stud[illegible] [illegible] od[illegible] processes... [and] stitutional inte[illegible] [illegible] icipation to many with fferent perspectives and special c[illegible], on a continuing basis over me".[23]

* "The selection of competent professionals to participate in the litical exercise proved to be critically important. This situation is alogous to that in chess or other games when inferior players tend to nsolidate their own bad habits rather than being stimulated to improved or spired play"[24]. To be useful, poli[illegible] exercises on the problems of global vironmental change would almost c[illegible] nly have to involve several of the ry top scientists who have been i[illegible] in recent assessment efforts, us their opposite numbers from th[illegible] of politics, finance, and dustry.

* "[O]ne of the most useful aspects of the political game was its ovision of an orderly framework within which a great deal of written alysis and discussion took place... [O]ral or written discussion of litical problems that arise during the game is one of its most valuable atures"[25].

* The "future history" orientation of the games' output makes them an cellent vehicle for exploring response options in terms of the time quences of coordinated action they imply. The requirement that such tions taken in the games be internally consistent, and that ways be found sustain them in the face of new problems, other groups' policy agendas, d wavering social will has often proved to be among the most powerful ols of policy analysis[26].

* The political games helped to refine future research priorities for chnical participants and their staffs by exposing them to the kinds of estions their political masters would need answered under a range of often conventional but still plausible future histories. If experience with litical exercises is any guide, we should expect that many of the tensibly useful answers now being sought by scientists and analysts ncerned with global environmental change are ones for which no policy ople are ever likely to ask the relevant questions. Conversely, we are kely to find a number of urgent questions emerging in the course of the licy exercises that scientists could have studied, but haven't. I ggested earlier that such practically important but understudied questions ght include "row assessments" of the net impact of policy actions across a nge of atmospheric components. More generally, I suspect that the design global environmental monitoring and data systems would benefit enormously from such policy experiments.

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In conclusion: The debate over global atmospheric change has now reached a stage at which further advances in coping with its practical implications will require much closer integration of political and environmental perspectives than has until now been the case. Some form of policy exercise, aimed at writing future histories of global atmospheric change and societies' responses to it, seems to offer the most likely prospects for fostering such integration. Over the next several years, several experimental policy exercises might profitably be conducted, each involving perhaps a dozen of the most informed and creative scholars and policy people concerned with global environmental change. The only way to discover whether we would really learn something useful from such an experiment will be to try it. At a minimum, I suspect it would be fun.

NOTES

1. See, for example, NRC (1988) and IGBP (1988).

2. The most concise statement of these central features is given by Schelling (1980), in a document that has substantially influenced the approach of this paper and on which I shall draw extensively. See also Clark (1986).

3. A large and increasingly perceptive literature exists on the uselessness of most forms of well- intentioned policy analysis. A smaller but more interesting literature has begun to confront the challenge of producing usable knowledge in the face on incomplete scientific understanding and politically fragmented messes (Lindblom and Cohen 1979; Wildavsky 1979). I deal with these issues in the context of development policy in Chapter 1 of Johnston and Clark (1982). World- scale "messes" are often termed "the global problematique".

4. The notion that incomplete science applied in policy contexts can usefully be viewed as a tool has been developed by philosopher of science Jerome Ravetz (1986).

5. Schelling (1983)

6. Cf. Crutzen and Graedel (1986), Darmstadter et al. (1987), Graedel and Crutzen (forthcoming) and Graedel (1989).

7. Clark (1985b)

8. Beanlands and Duinker (1983)

9. US National Research Council, 1981; Bolin and Cook, 1983; IGBP, 1988.

10. Jaeger 1983, National Research Council 1977, Bach et al. 1983

11. National Research Council 1979, 1981.

12. See, for example, Lindblom and Cohen (1979); Wildavsky (1979); Clark et al. (1979).

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13. Schelling, 1983.

14. For a more complete application of this framework to the case of the greenhouse effect, see Schelling (1983) and Clark (1985a), and Jaeger (1988).

15. For discussions of policy analysis and applied science in general as "craft work" see Ravetz (1971), Wildavsky (1979) and Lindblom and Cohen (1979).

16. See Clark and Munn (1986), Toth (1986), Toth (1988a,b,c).

17. Brewer 1986

18. Goldhamer and Speier, 1959.

19. Brewer and Shubik 1979: 101.

20. Brewer, 1986.

21. Brown and Peterson 1975; Brewer and Shubik 1979.

22. Clark, 1985b.

23. Brewer, 1986.

24. Brewer and Shubik 1979: 101.

25. Goldhamer and Speier 1959: 77-8.

26. Schelling, 1984.

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QUESTIONS OF SENATOR KERRY

Question 1: It is frequently said that because of global warming and other long-term environmental threats are international in scope, unilateral responses are not appropriate. Yet, at the same time, as you point out, the major impacts will have to be dealt with locally. How do we balance international, national, and local concerns in developing response strategies for dealing with global environmental change?

Response: First, by recognizing that effective response strategies will almost certainly involve action at each of these levels. Second, by realizing that the resources relevant at each level are for the most part non fungible -- ie. we will rarely face choices of whether to spend or allocate a given resource at one level or another. Third, by emphasizing the importance of US leadership -- unilateral or otherwise -- in setting the style and pace of international efforts to deal with global environmental change. The central question therefore seems to me less one of "balance" than of identifying and pursuing sensible objectives simultaneously at the local national, and international levels. Some specific suggestions follow.

The virtually unanimous conclusion of scholarship on human response to large-scale, long-term environmental change is that most of the response occurs at the local level the farmers, capitalists and consumers who, consciously or unconsciously, alter their daily activities to adapt to new conditions. A major and currently underemphasized need is therefore to determine what these individuals need to make their choices in a more effective and informed manner How soon, and how seriously, might rising sea-levels be expected to alter the value of and prospects for beach front property? How should a homeowner or factory operator contemplating a shift to natural gas factor the possible implications of a national policy to reduce carbon emissions in his or her thinking? What should a farming family make of the dust-bowl doomsday forecasts as it tries to shape a strategy for economic and environmental sustainability? Questions such as these cannot be answered definitively. But they can be answered better than they are being answered now, which is not at all. EPA pamphlets or Congressional constituent newsletters might be a good start.

At the national level, we need to recognize that most of what individual countries do will reflect their own perceptions of self interest. I see very little to be gained from lecturing China on its "obligations" to forego use of its coal reserves, or of Brazil to preserve its forests for our good This is especially true when the lecturing comes from a country that is the world's number one producer of carbon dioxide, that has cleared a large proportion of its native forests, and that persists in driving to the local Burger-King in 20 mpg

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"recreational" vehicles. If we want other countries, especially the less advantaged ones, to adopt environment-conserving practices we are going to have to take actions that make it both desirable and feasible for them to do so. This means helping to develop analytic tools (eg. appropriate methods for impact assessment or for comparing alternative energy technologies) that they can use to address their perceptions of global environmental change. It means helping to develop the kinds of technologies (eg. economical alternatives to coal combustion; soil-preserving tillage techniques) that let them get on with their development using their resources. It means, most difficult of all, helping to foster broadly based social and economic development that will be required if they are to have the luxury of contemplating present sacrifices for the future environment. Our conduct of foreign relations our trade and aid policies, and our notions of technology transfer and competitiveness all need to be examined with these requirements in mind.

At the international level, we need to recognize that environmental issues are joining traditional issues of military security and economic development as central terms of the international debate. America has been slower to recognize this than many countries, and has not yet evolved a view of foreign policy that takes into account the environment/ security/ economy connections. Our engagement in both the Montreal protocol discussions on ozone protection and the new Intergovernmental Panel on Climate Change reflect the bureaucratic politics of Washington more than they do a carefully thought out and widely discussed national strategy on the environmental dimensions of international affairs. Congress has a major and as yet unfulfilled responsibility to provide the forums and leadership that will be necessary if we are to evolve an international strategy for dealing with global change that is worthy of the United States Broadly based joint hearings would be one way to start the necessary dialogue.

Question 2: One of the suggestions you make for developing policy responses is to bring together policy people, scientists and technologists. What efforts are currently underway to follow such an approach?

Response: A number of bilateral efforts are underway in which policy people or business people are asking scientists to explain and discuss the issues of global change. These range from Congressional hearings and Executive agency advisory panels, to business initiatives like this year's World Economic Forum in Switzerland (Senator Bradley among others, was present) and the Partnership for Sustainable Development recently established by a group of Great Plains business people in Canada and the United States. In the Federal Republic of Germany, an unprecedented report on the science and policy of "Protecting the Earth's

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Atmosphere" has recently been released by the Enquete-Kommission of the Bundestag -- a commission composed of Germany's leading scientists, plus senior parliamentarians from every political party.

True multilateral discussions involving policy makers, business people, environmental advocacy groups and scientists have been much rarer than bilateral efforts. In 1987 the Beijer Institute of the Royal Swedish Academy of Sciences convened one such discussion at Bellagio in Italy, leading to an important international report on "Developing policies for climate change" (World Meteorological Organization, Geneva: WMO/TD- No. 225). The U.S. National Academy of Engineering hosted an open ended discussion at Woods Hole, Massachusetts last summer to explore technological opportunities in the management of global change. (A report will be published by NAE later this year). I believe that both the World Resources Institute and the American Energy Assurance Council in Washington have been trying to build a truly multilateral dialogue on responses to the climate change problem. And Congressman Dingle is leading an important effort to bring about useful discussions on global change policies amongst DOE, scientists, industry, and the environmental community. Other efforts to initiate multilateral, off the record discussions on possible responses to global change are doubtless underway. But the need is great, not just in Washington, but around the country. The opportunities for Congressional initiative -- perhaps through breakfast meetings, dinner gatherings, or more formal forums set up in home districts -- are substantial.

Question 3: Research on global change is interdisciplinary involving scientists in diverse disciplines. Yet at most American universities and in most federal agencies, facilities and research funding are allocated by discipline. I would think this would tend to discourage multidisciplinary and interdisciplinary research. Do you think that this is a serious problem? What should we do to encourage multidisciplinary and interdisciplinary research?

Response: Multidisciplinary and interdisciplinary research is certainly required to address the problems of global environmental change. This is increasingly recognized by the relevant scientific communities, as reflected for example in the new programs in Earth Systems Science at University of Pennsylvania, in Earth and Planetary Sciences at Harvard, in Climate and Global Dynamics at the National Center for Atmospheric Research, and in Sustainable Development of the Biosphere at the International Institute for Applied Systems Analysis. The need for, and potential of, multi- and interdisciplinary approaches is the motivation for the International Geosphere- Biosphere Programme as well as the US Global Change Program. To a gratifying extent, the central place

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of multi- and interdisciplinary research in an understanding of global change has also been recognized by the federal agencies most involved in funding US global change studies and by OMB.

Substantial barriers nonetheless exist between the widespread recognition of the need for multi and interdisciplinary research, and the accomplishment of such research. These barriers involve institutional rigidities within the universities and executive agencies, inadequate funding for interdisciplinary global change studies, and insufficient personnel to carry out those studies. I will discuss the first two barriers here, and reserve my comments on the personnel issue for the following question. (I will also use the term "interdisciplinary" to include both the relatively easy problems requiring merely that scientists from two or more disciplines collaborate, and the relatively hard problems requiring that individual investigators think, study and publish along lines that radically transcend their disciplinary training)

Steven Schneider, in a recent volume (Spring 1988) of the NAS journal Issues in Science and Technology, succinctly describes the barriers to interdisciplinary research on global change. Reforms are certainly needed in the academic community, especially in its quality assurance and promotions processes. But the most important mechanism for accomplishing these reforms is through the processes by which we fund interdisciplinary research. As noted above, many of the best researchers in the academic community are ready and able to conduct interdisciplinary studies on global change. Funding, however, is relatively difficult to obtain for such work. It is much easier, and much surer, to apply for support in traditional disciplinary areas.

As I discuss in my response to the following question, this is an insidious situation. For if even the best and established investigators find it difficult to obtain support for interdisciplinary studies of global change, universities are unlikely to expand their hiring and teaching in interdisciplinary areas but will instead focus on the established (and fundable) disciplines. Students are unlikely to pursue careers for which few if any new positions exist, and will also be drawn into traditional disciplinary paths. Inevitably, on the occasions when a certain amount of interdisciplinary funding does seem to become available, few researchers beyond the elite group already engaged in such research will have the experience to produce good proposals. The funding agencies will then cite the absence of a large number of fundable proposals for interdisciplinary global change research as evidence that significant funding for such work is not justified.

If we are to break out of this cycle, we need to develop mechanisms for moving adequate, sustained funding from the

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executive agencies to the best qualified individual researchers interested in pursuing high priority, interdisciplinary research on global change. The initial level of support need not be high, and need not be new money. What is essential is that it be targeted on the best work and workers, and that it be guaranteed over sufficiently long time periods that it can begin to draw talented young scholars into the field as a viable career choice.

How well are we doing at developing such mechanisms? Over the past two years the Committee on Global Change (CGC) of the National Academy of Sciences and the Committee on Earth Sciences (CES) of the Federal Coordinating Council for Science, Engineering and Technology have worked closely together in an effort to assure that the interdisciplinary research needed for a better understanding of global change is effectively defined, prioritized and supported in the President's budget. Key documents are the Academy's Committee on Global Change report Toward an Understanding of Global Change: initial priorities for US contributions to the International Geosphere-Biosphere Program, the CES preliminary report Our Changing Planet: a US strategy for global change research, which accompanied the President's FY 1990 Budget to Congress, and the CES more complete draft report US Research on Global Change: current and future.

The Academy committee, on which I had the honor to serve, produced a report that does in fact begin to meet the challenge of transcending disciplinary barriers and defining a small number of high priority, truly interdisciplinary research programs for initial pursuit by the US global change program. The CES reports strive to match that interdisciplinary integration, but fall short. I am convinced that CES is continuing a good faith effort to achieve an interdisciplinary perspective on global change and may well succeed in the future if its leadership is sufficiently determined and supported in transcending interagency turf battles. The fact remains that the US presently has no mechanism in place to target global change funding on the needed interdisciplinary research, and no mechanism in place to monitor the extent to which the target is reached. The scientific community, OMB, and the Congress need to make it absolutely clear to the executive agencies that, whatever their internal disputes, we require of CES such a mechanism in the very near future. Once the mechanism is in place, it will be all of our responsibilities to assure that adequate funding is made available to pass through it, and thus to sustain a high quality program of interdisciplinary research on the problems of global environmental change.

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Question 4: Do you think that American universities are producing enough talented scientists to tackle the problems you've outlined?

Response: This is an important question that deserves a more systematic answer than I have been able to assemble. I will endeavor, however, to see that the question of personnel requirements for improving our understanding of global change is taken up in the near future by the relevant committees of the National Academy of Sciences and the Federal Coordinating Council for Science, Engineering and Technology.

My personal impression is that the answer to your question is "No." The problem is not, I suspect, that too few good students begin graduate training in the relevant disciplines. It is rather that as the students approach the end of their studies and begin to look for career tracks, multidisciplinary studies of global environmental change do not look nearly as attractive as work in the traditional scholarly or applied areas. Many of the best students, even though they have a real personal desire to work on environmental problems that "matter" end up drifting off into other areas with more secure funding and better prospects of appointment to permanent teaching or research positions As a result even the best university labs doing work on global change are left often with a shortage of qualified researchers With so few new global change researchers coming "down the pipe", the same senior scientists are called on over and over again to serve on planning committees, testify at hearings, and perform peer review evaluations. As a result, the global change research system may well be people limited.

How could this be true at a time when so much attention is being given to global change, and significant new money is being allocated by a concerned Congress? I don't know. But the impression I share with many of my colleagues is that most of the new money set aside for global change studies is simply not getting to the individual university research labs that are our major source of graduate training, our major home for innovative basic research and, ultimately, the foundations upon which we build our understanding of global change. Where do the funds go? Facilities? Contract research organizations? National labs? In-house agency studies? Planning? Paper studies for Congress? Again, I simply don't have the data I need to answer this question with confidence.

My guess is that we need to find better ways of guaranteeing that the real needs for space-based observations and "big-science" coordinated efforts in a global change program do not leave individual university investigators, and the training programs that they run, starved for support. EPA's Science Advisory Board, struck by the shortage of trained environmental scientists

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and engineers in general, has already recommended a major increase in the portion of that agency's research funds allocated through peer-reviewed, investigator-initiated grants to colleges and universities. Similar recommendations have come from the environmental engineering community. Congress should help the agencies to take such general advice seriously while awaiting the careful delineation of needs for support of training and career-track development in global change studies.

In the meantime, it might be useful to consider a new program of postgraduate and junior faculty fellowships for research on global change -- fellowships that would offer a level and duration of support to make careers in global change research more attractive to recent PhDs. Such a program could be administered on a competitive, peer-reviewed basis by NSF or the NRC, emphasizing originality and interdisciplinary problem definition. Such a fellowship program need not be expensive, and could even be defended as a means for allocating some of the funds already earmarked for global change research. It could embody a timely, efficient, visible and effective commitment to improving our understanding of global change.

Senator GORE. Thank you very much.

First of all, other members of the committee have expressed the desire to submit questions in writing if you all would be willing to respond to them.

Is it safe to say that all four of you support the Chairman's bill and believe it should be enacted?

Mr. LAMBRIX. Absolutely.

Dr. DRABENSTOTT. Yes.

Mr. CLARK. Yes.

Mr. RILEY. Yes.

Senator GORE. Mayor Riley, the Chairman gave you his personal welcome. I want to extend mine also. We did not have a chance to visit before the hearing today, but I certainly enjoyed getting to know you, your family and your city when we took our vacation there this past summer. I already had great admiration for your leadership, not only in Charleston, but nationwide as one of the great leaders of all of America's mayors.

And, as the Chairman already noted, your testimony today was really outstanding in its comprehensive perspective, and I really do appreciate it.

You mentioned the word stewardship which informs my commitment on this issue. My Bible says that we are given dominion over the earth, but we are required to be good stewards of the earth. And if we witness a poisoning of the earth's environment in our lifetimes as a result of our actions—to the point where we have a larger effect on weather and climate than any force of nature—then we will have not fulfilled our charge to be good stewards. And I certainly appreciated that in your statement as well.

I am impressed that under your leadership Charleston is doing such detailed analysis of exactly what the consequences might be. The scientists tell us that this is most appropriate.

With respect to the issue of sea level rise, there are many consequences of global warming. These include the migration of insects northward, as you indicated, and changes in rainfall patterns and temperature distribution. But sea level increase is also a factor.

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The cause of sea level rise falls into two general categories, as I understand it. First, there will be an increase in sea level due to the thermal expansion of the oceans as the distance between the molecules increases with the warming of climate. A further increase would be due to the melting of glaciers. Because of those two effects, we have seen an increase in sea level already of about 10 centimeters in last 100 years, corresponding to the increase in temperature of approximately 1 degree Fahrenheit over the last 100 years on a global basis.

Now, have you noticed and have the old-timers in Charleston—I know your dad is a great student of history and embodies a lot of it himself—have the old-timers noticed any effects as a result of what the scientists say has already been a 10 centimeter increase in Charleston?

Mr. RILEY. Senator, I would think so. We have seen changes in a number of our coastal islands. We know they all move and are migrating, but there seems to be a net diminution of the tidal shore area on the sea islands. And so, I would think that even that small change has been noticed even though very gradually. And, of course, what we are looking at in the next hundred years is possibly a change, at least ten times as great if not more.

Senator GORE. Well, again, there are two categories. And it is the first category of sea level rise that we are in now. In our lifetimes the mid-range estimates are that we will see a four degree Centigrade rise in temperature, and that is associated with an increase in sea level of one half to one and a half meters.

Then, in the next, 200 years or perhaps later, scientists predict a more dramatic increase in sea level due to a sudden breakup of the west Antarctic ice sheet which evidently did happen in geologic time, perhaps more than once. And that would lead to a sudden increase in sea level many times what this gradual increase from thermal expansion and glacial melting is causing.

But you bring it down to earth in talking about what the impact at Charleston is going to be.

Let me come back to it, but let me ask you, Dr. Drabenstott. When I was in Kansas last weekend, they told me there is still a drought going on in spite of the snowfall which came in the last couple of days. Is that the way you see it?

Dr. DRABENSTOTT. Clearly the winter wheat crop is experiencing very dry weather and because we also had dry weather during the planting season last fall, the crop did not get established as well as people would like to see. That has left it vulnerable to cold weather without snow cover.

Ironically, the winter wheat growers of Kansas did extraordinarily well in 1988 because their crop was unaffected by the drought, and they benefitted by the sharp run-up in prices.

Now, almost, they are getting their turn. If we do have a good rainfall this spring, we still could see an average crop in my judgment.

Senator GORE. Well, again, dealing with the uncertainties that surround the global warming issue, it is fair to say, I think, that there is little disagreement about the fact that temperature worldwide has increased over the last hundred years and that the increases in greenhouse gases will cause a further increase.

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But, where moisture distribution is concerned, the uncertainties become much greater. All the scientists will tell you that when they look at their computer models and try to predict rainfall, it is much harder than it is to predicting temperature increase.

But, again, all of the computer models tend to point toward a drying out of the areas in the middle of the great continents. That is because the evaporation of moisture from the soil soon after it falls is increased as a direct function of increases in temperature.

Eight years ago in the first hearings on this issue, scientists were predicting droughts in the Great Plains. And, as indicated earlier, the Great Plains have had periodic droughts every 20 years on average since America has existed.

But, this area has also been vulnerable to droughts because of the relative moisture content in the soil and the character of the soils in the Great Plains.

Have you looked at these factors in your projections for the agricultural markets and the bankers that are so sensitive to crop projections? Have you looked at the predictions about worldwide grain shortfalls because of this problem?

Dr. DRABENSTOTT. Senator, it would be my view that we entered 1988 with very substantial stockpiles in the U.S. and worldwide.

After the 1988 drought, we have seen U.S. stocks drawn down dramatically. I would note, however, that weather was generally favorable in many other major producing parts of the world last year, so that global stocks have not been drawn down as sharply as they have in the U.S.

As I indicated in my testimony, both in my oral comments and in my written testimony, it is my view that we are going to have to take a closer look at what our grain stocks policy has been.

We had big stocks in the U.S. entering 1988, primarily because we had used farm commodity programs to transfer income, not because we had used them to build stocks. So I think there is a valid case to be made for reexamining our stocks policy.

If we are entering a period of significant global weather change, the United States and other major producing countries need to take a look at how big gain stocks ought to be in a period of greater volatility. In the past, countries have not been able to agree very well on the world front as to who should hold those stocks.

By default, the U.S. has held most of them in the past. I think the issue of who should hold the stocks is one that needs to be aired in a global forum.

Senator GORE. Well, if you look at worldwide grain production, there has been a steady increase since World War II with some fluctuations and occasional downturns.

Correct me if I am wrong, but it is my impression that if you look at the overall pattern we have seen during the last four years, it is the first period in which there has been a slight but steady decrease in worldwide grain production.

Now, I am not talking about stock management now, I am talking about production, annual production. There has been a worldwide decrease in production each year for the last four years.

Do your figures reflect that also?

Dr. DRABENSTOTT. I cannot recall all of the world grain production figures off the top of my head.

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But I think there has been a stagnation of world grain trade, and I think some corresponding leveling out in production.

Senator GORE. I think it is more than a leveling out. I think it has been going down each of the last four years.

And whereas in the past, a downturn in one area commonly would be accompanied by an upturn in some other area, in the last few years we have seen a simultaneous downturn in most of the large grain producing areas.

This may make it timely for us to push hard for global grain agreements to deal with the management of stocks and pricing, as well as the use of surpluses when they occur for dealing with the enormous hunger problems in the world.

Mr. Lambrix, I appreciated your statement on behalf of the NAM. I have been involved in this issue for so long that I get frustrated from time to time when people tend to minimize what we know, and what many of us believe is ample justification already for acting.

On the other hand, I understand it is hard for the business community to accept predictions that would have such enormous consequences, if they are valid, without being absolutely sure.

I would say this, though, when you make a statement on behalf of the NAM that scientific evidence regarding enhanced global warming is inconclusive.

I would urge you to take the message back to the NAM that the day is quickly coming—and I am speaking for myself here and not for the committee—when the business community is going to be called upon to be much more precise in its view of this issue.

There are some things that are inconclusive, there are some things that are not inconclusive. And U.S. businesses are, like all businesses, properly averse to risk. That is only sensible.

But there are profits to be made in being the first to recognize a business trend that will, for example, open up brand new opportunities in the production of substitutes for chlorofluorocarbons, new technologies for making appliances and engines far more efficient, and the like.

Our whole society has a terribly difficult time wrestling with this issue, because the consequences are so vast, they are so unprecedented in all of human history, and the solutions are almost unimaginably difficult.

But our traditional historical response, when confronted with a challenge of that kind, is to say, wait, let us get more facts, let us get more evidence. Let us not do anything rash, and let us do not move too quickly. I have long since come to the conclusion that such a traditional response is no longer acceptable.

If we are going to fulfill the responsibilities that Mayor Riley referred to as stewardship, I just think that it is abundantly obvious that we must act.

I do not know if you have ever seen a computer-generated picture, like Abraham Lincoln or the United States, where they have these big blocks of color or light and dark. You get close to it and you cannot see what it is. It is just a jumble. But when you stand back a little way, it is just as clear as day.

The picture jumps into focus. That is really what this problem is like. You can look at a small part of it from up close and it is

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almost impossible to see any pattern. You spend a little time standing back off from it, and looking at all of the components together, it is just as plain as day.

The emissions that cause the problem have increased steadily. The evidence is there. You have to see it on a global basis, you have to stand back and look at the whole world. And you have to look at it over a little bit of time.

And the aversion to the use of the word "crisis" or "crisis management," is also quite understandable and, in other circumstances, would be appropriate. In my view, however, we have a crisis right now.

On a time scale of decades, it is a slow motion crisis. But if you look at it in terms of the irreversible damage if we continue along our current pattern, it is a crisis. And, in my opinion, we should act right now.

Now, you look like you want to respond to that, and I want to give you a chance.

Mr. LAMBRIX. Yes, I would like to, Senator. I do not think we take issue over much of what you said.

I think what we are asking for is that we be prudent in the steps that we ask U.S. business in our society to take, recognizing the global nature of the problem, recognizing that the United States has taken a leadership role in working through the IPCC, and in other international fora.

We agree with the three-pronged approach under way, scientific review, analysis of impacts, and development of response strategies. We are not taking issue with any of that.

We also believe that there are steps that businesses and others can take that make sense in their own right. We agree with Secretary Baker's comments that, let us look at cost-effective steps, but let us also act to do things that are both for the benefit of the environment and the economy simultaneously, things that make sense in their own right, we should do. We support that.

But we do not believe that the time is right, and perhaps we just disagree on this, that we are in a period where mandatory or massive intervention in society by the government to address specific responses are called for at this time.

For example, I agree with Senator Stevens' comments he made earlier about the climax forest issue. Dr. Corell also pointed out the uncertainties that we still need to look at in the modeling area such as the biological contributions in terms of methane and the role of clouds and the role of the oceans.

We think the program as outlined in this bill is the right approach at this time. We are prepared to take steps that make sense in their own right.

Senator GORE. Okay, we still disagree though. I want to be clear about it.

I think this is a terrific bill too. I join the chairman in pushing it forward, and am proud to be one of his co-sponsors. But where you and I disagree, I think, is that you believe that this bill alone is sufficient, at least for now, and I do not think that is correct at all.

You have said that you are looking at this issue—you probably have not looked at it for very long. You have been very cooperative

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in responding to our invitation to come, and you have given good testimony. I appreciate it.

But all I am saying is that the time is now at hand when the National Association of Manufacturers and more broadly, the business community, must come to the position that not only research, but also response action, is needed.

Anyway, I just wanted to make that point. Mayor Riley?

Mr. RILEY. Senator, first of all, I apologize, I have to leave to catch a plane to be back for a hearing in Charleston, and I would just like to thank you for your leadership on this issue.

What you said about CFCs earlier is so right. Our country has no credibility in the world, with all of the CO_2 we are sending up there. If we do not begin to limit that—I shaved with my old mug this morning—and all kinds of ways we can do things without using aerosol and others.

And we just have to, we cannot wait on that one. We really cannot. And we lose our credibility. And I commend you for your leadership. Our country needs it. And we welcome it.

And lastly, a different issue, the Federal Coastal Zone Management Act, which I think is up for reauthorization this year in terms of the rising sea level, it is a critical tool for our coastal communities.

I will leave this for the committee. This is a special area management plan that the city did in conjunction with the South Carolina coastal council, which administers the Federal Coastal Zone Management Act.

And it is a key ingredient of linking the local communities with the national government to develop a well-thought out plan. And I would just like to say how important that is and hope that it is reauthorized this year.

Senator GORE. Well, thank you, Mayor. And before you leave, I wanted to thank you as well for your reference to recycling.

And I will send you a copy of the legislation that I introduced the first day of the new Congress, the first nationwide recycling and waste minimization bill, and look forward to working with you on that. Thank you very much for coming.

And to our other three witnesses, we are going to finish up very, very shortly here. Dr. Clark, you referred to different response strategies and to different faces the issue presents to different countries. And I thought that you were attempting to get recognition a moment ago.

Did you want to respond to something that was said? Sometimes these other countries can respond to the face they see on the issue without paying attention to other aspects of it.

Brazil, for example, is angry at any attempt by nations in the industrialized north to impose upon them some mode of behavior in the Amazon that they think challenges their sovereignty over that area. They spend so much time being angry about that that they had very little energy left over to realize what the consequences are for Brazil herself, with the loss of rainfall, the erosion of world famous beaches at Rio and other problems.

You mentioned, Mr. Lambrix, about Senator Stevens' comments earlier on climax forests. One of the things that, even though climax forests do not absorb CO_2, they do generate, particularly in

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the tropical areas, a lot of the rainfall that determines the climate system in those areas. And Brazil, as an example, will lose rainfall as the Amazon is cleared.

I do not know. That is what I thought when you were talking about the different faces that the issue presents to different countries. I have some other questions, as do other members of the committee, which we will submit in writing.

But I heard somebody's stomach growl a minute ago, and we have gone quite a long ways in the hearing today. On behalf of the chairman, I want to thank all of you for your support of S. 169.

I want to say again that the space and science subcommittee will be convening tomorrow morning in this room at 9:30 on the Arctic and Antarctic ozone depletion problem.

I would like to thank all of our witnesses today. And this hearing is adjourned.

[Whereupon, at 12:30 p.m., the hearing was adjourned.]

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ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT BY ALEXANDER B. TROWBRIDGE, PRESIDENT, NATIONAL ASSOCIATION OF MANUFACTURERS [NAM]

Thank you and good afternoon. Thank you for this opportunity to speak before the United Nation's first meeting of the Response Strategy Working Group of the Intergovernmental Panel on Climate Change as a representative of the International Chamber of Commerce (ICC) at the request of the United States Council for International Business.

Although the International Chamber of Commerce does not yet have a formal position regarding global climate change, it expects to formulate one in light of the outcome of these meetings. I have been invited to participate by this organization as president of an organization representing 13,500 U.S. manufacturing companies and subsidiaries, and the broader concerns of industry as well. I believe my views are consistent with statements given by other U.S. and non-U.S. industry groups while, officially, I only represent the National Association of Manufacturers (NAM). I should note that the International Chamber of Commerce will be assisting the British Government with the organization of its forthcoming conference on "Protecting the Ozone Layer."

Climate change is a global issue and should be addressed through an international forum. Although multinational treaties on environmental issues are relatively new, they offer the promise of sound and workable policies implemented multilaterally. A unilateral response to a global problem is inadequate; an individual nation's contributions compared to all sources, may be small, but the costs of such actions will be detrimental to that nation's economic competitiveness.

The NAM firmly and enthusiastically supported the Montreal Protocol to protect the earth's stratosphere. Industry supports the Montreal Protocol, which provides an international framework for protection of the stratosphere and ozone layer and CFC controls. Associations, such as NAM and the ICC, urged that the Protocol be ratified and have called for further scientific review to determine if the timetable for the phase-out of CFCs needs to be stepped up. Beyond the Protocol agreement, U.S. industry is working diligently to adapt its manufacturing processes to reduce CFC emissions and order to develop and use non-ozone depleting substances. The scientific, technical, and economic review requirements lend strength to the Protocol while allowing it to be flexible.

The NAM believes that industry must continue to actively involve itself in research efforts and the development of response strategies to global climate change as it did in the ozone depletion matter. This research program is especially essential as scientific evidence regarding enhanced global warming is still inconclusive. Moreover, we do not understand many scientific theories about the carbon cycle regarding feedback mechanisms such as cloud formation and the role of the ocean as a heat and CO_2 sink. Just as we continue to be concerned with the ability of our planet to adapt to climate change, we must be equally concerned with economic shocks to our global economy. Precipitous changes in energy supply and use changes could cause severe jolts to our global economy and severely hurt the development of the Third World.

The NAM is concerned about the global climate change issue and the questions related to any enhanced warming trend or the so-called "greenhouse effect." It is a large challenge for scientists, governments, public policy makers, and business to make certain that global economic development is sustainable and does not cause irreparable damage to our planet. But we must be certain that whatever international actions are taken will encourage economic growth with sound environmental policies for all nations.

I am encouraged to see the United Nations address both the many uncertainties associated with impacts of global climate change and the possible responses to this complex problem. I trust this effort will prosper and culminate in sound science and

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sound multilateral policy objectives under the direction of Dr. Mostafa Tolba, executive director of the United Nations Environment, Programmme, and of Professor G.P.O. Obasi, Secretary General of the World Meteorological Organization.

However, let me convey to you American industry's concern that as in all public policy matters, policy decisions on enhanced global warming should be made only after weighing the scientific understanding and potential socioeconomic impacts of this phenomenon. This task ahead for world leaders, scientists, and business leaders in a daunting one. But, we are encouraged that the IPCC has established three working groups to address the science, the impacts, and the possible response strategies—and we support your efforts.

There is no doubt as to the role of American industry in the resolution of this scientific and public policy debate. As you all known, American industry is a substantial provider and consumer of energy and has made great strides in energy conservation. In addition, approximately 4% of all U.S. industrial capital expenditures are spent on pullution abatement. These activities include groundwater protection, improved waste management, hazardous waste cleanup, forest and wetlands protection, and clean air and clean water enhancement. Industry will continue to act in an environmentally responsible manner.

CONCLUSION

The NAM is concerned with the global climate change issue, and we support a multilateral approach such as this effort by the IPCC. We strongly believe that the first priority should be scientific research. All scientific research should be directed to confirm or refute the theory of "enhanced" global warming caused by increases in greenhouse gases.

In addition, we support accurate and balanced public education to increase our understanding of what is and what is not known about global climate change. Our first priority is to obtain a better understanding of the factors contributing to global climate change, then to help educate the global society about options that are available to mitigate potential effects, and what the costs and relative effectiveness of each measure will be.

We also need to avoid taking crisis measures in addressing the global warming issue. Given the uncertainty in science, policies that make sense in their own right are preferable to mandated measures. Conservation, for example, is a worthy goal, but inefficient reductions in energy use will have harmful effects on our standard of living.

In conclusion, caution is also advisable because of the contributions that other nations will make to growing concentrations of greenhouse gases. The U.S. obviously cannot solve this problem alone, and if society is asked to make changes in energy uses and lifestyles, we will have to sustain policies across national boundaries and through changes in the policies of governments. Societal changes can only be accomplished if they are preceded by sound science that links theroy to fact and clearly demonstrate that such actions are warranted.

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Comments of The American Petroleum Institute
to the
United States Senate
Committee on Commerce, Science and Transportation
Hearing on
The National Global Change Research Act of 1989 (S.169)
February 22, 1989

The American Petroleum Institute (API), which represents over 200 corporate members engaged in all aspects of the oil and gas industry, exploration, production, refining and marketing, appreciates the opportunity to comment on the National Global Change Research Act of 1989 (S.169.)

API supports passage of this legislation, which is a useful step toward the institutionalization of U.S. research into global climate change. It is entirely appropriate that the United States seek the best way to apply its considerable scientific and technological assets via an active program focused on the goals of improving understanding of the physical, chemical and biological forces that shape climate, of assisting in the world-wide effort to monitor climate changes, and of providing decision makers with more reliable estimates of future global climate trends.

API recognizes that empirical scientific evidence documenting an increase in the levels of infra-red absorbing "greenhouse" gases in the atmosphere has led atmospheric scientists to project an increasing average world temperature.

API is also aware that many uncertainties exist in the methodologies on which predictions of climate change are based. Those predictions are based on sophisticated mathematical models that attempt to simulate the forces that determ ne climate. But current knowledge of those forces is imperfect because we lack an adequate understanding of the interactions of the components of the exceedingly complex climate system which include not only incoming and outgoing radiation and greenhouse gases, but also clouds, oceans, ice cover and vegetation, to name just the most obvious factors.

A recent New York Times article portrayed scientists as "struggling to understand a host of bewildering interactions among air, water and plants that could hasten ... postpone or produce unexpected rapid change in the earth's climate." Because of this basic uncertainty and the lack of global verification data, the accuracy of the results given by even the best current models is unknown. As NASA Assistant Administrator for Space Studies and Applications Lennard A. Fish has pointed out, no currently available model has sufficient accuracy to predict credibly the timescale, magnitude or regional impact of a global warming trend.

The legislation currently before this Committee would increase U.S. ability to establish a sound and credible basis of scientific research into climate change, an aim that API fully endorses. S.169

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constructs an institutional basis for the useful recommendations of the recent report by the Committee on Earth Sciences entitled: "Our Changing Planet: A U.S. Strategy for Global Change Research." It is appropriate that the Office of Science and Technology Policy oversee the development of "long range and coordinated plans for scientific and technical research in the area of global climate change." S.169 would wisely allow Executive departments and organizations to continue those established programs in which they have demonstrated expertise, thereby avoiding disruption of the existing research effort.

API agrees also that all federal research activities associated with global climate change should be identified in an integrated manner in the Federal budget, which would foster improved understanding of the scope and direction of the program by interested parties and improve our ability to identify data gaps or organizational overlap.

The greatest research effort should be placed in those areas likely to have the greatest impact in reducing the scientific uncertainty currently faced by policymakers. We recommend that, as a first order of business a federal coordinating body should analyze the magnitude of the uncertaint es implicit in the forecasts of future climate change. Then research priorities should be established and estimates developed as to when it can be reasonably expected that specific uncertainties can be reduced significantly. These timeframe estimates should also incorporate the time required to generate monitoring data sufficient to document global changes and validate the tools for future projections. Such a procedure, API believes, provides a rational way to develop a long range plan for the United States and could also serve as a model for the international effort.

API also recommends that full advantage should be taken of the considerable intellectual and scientific resources available from industry To this end, we strongly suggest that the counsel of the private sector should actively be sought in developing research plans to address the scientific aspect of the global warming issue. A formal and public peer review process should be established within the executive branch to oversee the progress of the program and the quality of the scientific results obtained.

The plan described in S.169 calls for a major re-evaluation every three years. While API agrees that such a re-evaluation should occur no less frequently than that, we suggest that developments in science should act as a guide to determine if and when more frequent mid-course corrections are appropriate.

Despite the background of fundamental scientific uncertainty regarding the significance of increasing concentrations of greenhouse gases, there have been calls from some quarters for the imposition of controls on emissions of those gases. API believes that those calls should be viewed from the perspective of the principle enunciated by Dr. Patrick Michaels, a professor of environmental sciences at the University of Virginia in the Jan. 8, 1989 Washington Post: "Our policies should be no more drastic than the scientific conclusions

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they are based upon."

In other words, the rigor of policy alternatives adopted by decision makers must be consistent with the definitiveness of the science. While a principal role of policy in this case is to delay global warming, the role of science is to provide a direction and scope for policy development. Accordingly, progress in the scientific and public policy areas must be parallel, with each informing the other.

In summary, API believes that a well-coordinated federal research effort yielding rigorous scientific conclusions is critical for the development of rational policies and response strategies in the area of global climate change. S.169 will assist this process.

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AMERICAN NUCLEAR ENERGY COUNCIL

Edward M. Davis
President

February 15, 1989

The Honorable J. Bennett Johnston
United States Senate
Washington, D.C. 20510

Dear Senator Johnston:

Recently, you may have received a letter from Ralph Nader's Public Citizen which erroneously suggests that U.S. government policy should dismiss the potential role of nuclear power in reducing greenhouse gases, specifically carbon dioxide. We are writing to suggest that no option for meeting the growing demand for electric power in the future can be ignored.

Nuclear energy plants are one alternative for electricity supply which emit no carbon dioxide or other combustion products. In 1987, U.S. nuclear power plants reduced total U.S. carbon dioxide emissions by almost 9%, and the world's nuclear plants reduced global carbon dioxide by over 7%.

The federal government must continue to support programs which enable the Congress and the Administration to shape the U.S. nuclear technology of the future. In response to Congress and the needs of the electric utilities, the U.S. DOE's advanced reactor program and that of participating private companies have developed new reactor designs. These designs build on 30 years of worldwide operating experience and incorporate the lessons learned. They are simpler to construct and operate. They incorporate passive safety features which greatly simplify response to complex situations.

Some reactor designs incorporate innovative fuels, modularized construction approaches and down-sized units which provide flexibility for the technology to respond to changing needs of the electric utilities. The increased simplicity and modularized construction approach of advanced reactors should reduce the capital and maintenance costs of the next nuclear energy plant.

Some new reactor designs are currently reaching completion; one new U.S. design has already been ordered for construction in Japan. Other designs will be available for introduction into commercial power grid in the next decade. The NRC is currently

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in the process of certifying three of the new designs, which could qualify them for licensing by 1992. Work on the more advanced design continues, and some of these may require prototype verification prior to commercialization.

The need for U.S. policy to resolve the impediments to the revitalization of nuclear energy has never been greater. If the safety, economic, and environmental benefits of advances in nuclear technology are to be available to the U.S., Congress must complete ongoing federal efforts for advanced reactor development, the waste disposal program and regulatory improvements, such as standardization and licensing reform.

Please contact the Council for more information on nuclear electricity.

Sincerely,

Edward M. Davis

Edward M. Davis

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AMERICAN ASSOCIATION OF NURSERYMEN
1250 I STREET, N.W. / SUITE 500 / WASHINGTON, D.C. 20005 / 202/789-2900

Testimony
before the
Committee on
Commerce, Science and Transportation
United States Senate
February 22, 1989

The American Association of Nurserymen (AAN) welcomes this opportunity to present the views of the nursery and landscape industry with respect to global warming and, specifically S.169 -- the "National Global Change Research Act of 1989." The views presented herein are also endorsed by the Wholesale Nursery Growers of America, National Landscape Association, and the Garden Centers of America.

AAN is the national trade association of the nursery, landscape and garden center industry. We represent approximately 4,000 firms across the country engaged in all segments of the industry -- nursery farming, landscape contracting and garden center retailing. By almost any standard, our members are primarily small family-owned farms and businesses. The retail value of nursery crops sold in the United States in 1987 was estimated to be $6.35 billion.

Mr. Chairman, obviously there is growing concern about the ecological stability of our global environment. Recurring droughts, tropical deforestation, expanding desert regions and acid rain appear either to be changing the earth's climate or represent changes which have already occurred. The prospect of global warming holds dramatic public policy implications with

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respect to environmental and energy policies. Unfortunately, conflicting theories based upon a general lack of scientific data, and understanding thereof, pose formidable obstacles to the effective implementation of public policies which may reduce the risks associated with climatic changes such as global warming.

As proposed, the "National Global Change Research Act of 1989" (S.169), represents the nucleus for improved coordination of national scientific research efforts. The legislation provides a national blueprint to improve scientific understanding and prediction of the effects of global climatic changes. AAN is pleased to endorse S.169 as it represents an essential first step toward consideration and implementation of effective energy and environmental policies to address global warming. We must begin to understand the true scope of any global climatic problems before national resources can be wisely committed to mitigate its effects upon the environment, agricultural production, energy consumption, industrial development and overall standards of living. Certainly, the prospect of global warming demands nothing less than the close and effective coordination of federal and private research efforts. The outline of federal agency responsibilities and research priorities, as provided in S.169, goes a long way towards this realistic goal.

Five of the warmest and driest years on record in the United States have all occurred during the 1980's. Droughts threaten agricultural production and tax our precious water

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resources. Tropical forests are being deforested at an estimated annual rate up to 27 million acres. Air pollution is contributing to acid rain and thereby damaging forest ecosystems. Carbon dioxide is reported to be increasing at the rate of one-half of one percent each year.

Planting trees and shrubs can help reduce fossil fuel consumption which is believed to be the major factor in carbon dioxide buildup which contributes to global climatic changes. By providing a cooling canopy, strategically planted trees and shrubs can simultaneously reduce energy demands and cooling costs. By shading homes, offices and industrial buildings, trees and plants can make cities cooler and, certainly, more livable and environmentally sound. Foliage plants inside our homes, businesses and offices can sponsor similar environmental change, as well as carbon dioxide exchange...only indoors. While tree

While tree and shrub plantings will not cure the whole problem of global warming or climatic change, they represent a cost-effective approach which can be undertaken immediately -- while federal research programs are on-going. AAN has pledged support to the "Global ReLeaf" program launched by the American Forestry Association to plant 100 million trees in our cities and towns by 1992 to meet the growing challenges of global warming. It has been reported that this nation's carbon dioxide emissions can be reduced annually by 18 million tons just by filling the 100 million planting sites around homes and in cities

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and towns. Moreover, such efforts will reportedly save consumers an estimated $4 billion in annual energy costs.

To this end, AAN strongly urges this Committee to examine and incorporate into Section 602(d)(1)(F) of S.169 the approach already embraced by S.324-- "The National Energy Policy Act of 1989," which has been introduced by Senator Wirth and which you, Mr. Chairman, and several of your colleagues on this Committee, have cosponsored. Title XI, Subtitle A, Section 1103 of S.324 reads as follows:

> SEC.1103. URBAN FORESTRY AND ENERGY SAVINGS.-- The Secretary of Energy, in consultation with the Secretary of Agriculture, and other relevant government agencies, shall conduct a study of the potential for reducing carbon dioxide emissions by undertaking targeted urban tree plantings designed to reduce the air conditioning needs of buildings. The study shall provide estimates of the cost-effectiveness of such a program and shall outline a range of Federal, State, and Local public policies and incentives that would encourage public and private efforts to undertake such plantings.
>
> The Secretary shall complete the study and submit it to the Congress within 18 months after the date of enactment of this Act.

This directive in S. 324 represents a solid first step towards the articulation of new policy goals needed to foster ecological stability in our global climate. We suggest that not only should this important provision found in S.324 be incorporated into S.169 but that it be expanded to authorize community grant or cost-share

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programs to encourage aggressive energy conservation through urban tree and shrub plantings. Authorization for a research program of this nature will enable this nation and our industry attain heightened understanding and recognition of the energy conservation-related benefits of tree and shrub plantings.

Mr. Chairman, the prospect of global warming demands the immediate and determined attention of this nation. S.169 is well-drafted and will begin to foster the coordination of needed federal efforts. With the additions noted herein, S.169 will pose a formidable tool with which this nation can begin to commit necessary public and private resources. The nursery and landscape industry serves to improve and beautify the environment in which we, as Americans, are fortunate to live. Tree and shrub plantings represent a cost-saving and aesthetic step which this nation can immediately take towards the reduction of the risks associated with the prospect of global warming. Trees and shrubs have a positive role to play and hold immediate benefits as this nation begins to address these environmental issues. The American Association of Nurserymen applauds the introduction of S.169 and urges your consideration of the important points raised herein.

Thank you, Mr. Chairman.

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STATEMENT
on
THE NATIONAL GLOBAL CHANGE RESEARCH ACT (S. 169)
for submission to the
SENATE COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION
for the
U.S. CHAMBER OF COMMERCE
by
Susan C. Moya and Tertia R. Armstrong*
February 28, 1989

The U.S. Chamber of Commerce, the world's largest federation of businesses, state and local chambers of commerce, and trade and professional associations, appreciates this opportunity to express its views on S. 169, "The National Global Change Research Act" introduced by Chairman Hollings. The Chamber commends Chairman Hollings for his legislation and supports in principle the bill's provision to coordinate federal research efforts and to establish a multi-year research plan on global change caused by clinate and other factors. These comments incorporate the Chamber's strategies for action on global climate change.

Introduction

Global climate change is a major scientific and political issue. Although numerous articles on the subject have been written within the past year, including cover stories in both Time and Newsweek, conflicting information abounds.

There is no scientific doubt, however, that if certain trace gases in the atmosphere, notably carbon dioxide, methane, certain chlorofluorocarbons, and nitrous oxides (commonly called "greenhouse gases") accumulate to some critical point, the heat radiation from the earth will be trapped and the atmospheric temperature will increase. But what is not known is the critical point and when that point will be reached.

* Susan C. Moya is Manager, Energy and Natural Resources Policy.
Tertia R. Armstrong is Associate Manager, Environmental Policy.

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The Chamber believes that any man-made climate change is cause for the most serious concern and action -- the right action -- because the wrong action can be just as serious.

Chamber Action Strategy and S. 169

The Chamber recently distributed to Members of Congress its discussion paper Global Climate Change: Cause for Concern, NOT Panic, which suggests parallal courses of action.

The first course is to gain a better scientific understanding of global climate change in order to improve the capability to predict and respond to such changes, whether naturally occurring or the result of man's activities. S. 169 would start us on this course by directing, prioritizing, and beginning to institutionalize federal interagency global climate change research efforts.

The second course of action is to take those steps that make sense now, on their own merits, regardless of whether or not the global atmosphere is warming. Of course, the U.S. must play its fair part in such activities, but it is important to recognize that this is a global problem that requires international cooperation. No one country's actions, however ambitious, can significantly affect global climate change.

Currently, as many as nine national and international organizations are involved in global change research activities. No fewer than 12 U.S. federal departments and agencies are attempting to understand the Earth as a global ecosystem. Clearly, these organizations need prioritized goals, plans, and a framework for their research activities. S. 169 provides such coordination, focus, and structure through the Federal Coordinating Council

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for Science, Engineering, and Technology, part of the Executive Office of the President.

Reliable information, predictions, and assessments of tha complex phenomena of the global system are important. For example, global warming could require changes in agricultural policies, modes of energy production and usage, use and protection of natural resources, and coastal-zone management. The Chamber encouragee scientists around the world to work toward a better understanding of global climate change. S. 169 recognizes thie need by requiring that there be "further international cooperation in science, engineering and technology."

All federal global climate change rasearch activities should be identified in an integrated manner in the federal budget, as provided in S. 169. This is necassary to help to eliminate duplicative efforts, to identify data gaps, and to provide for improved understanding of the scope and direction of the program by interested parties.

S. 169 provides that federal egencies and departments should continue established programs in which they have demonstrated expertise. This would avoid disruption of existing research efforts. The Chamber supports this continuity.

As research plams, such as thoss proposed in S. 169, are being formulated, the Chamber hopes that the following questions will be given high-priority conaideration. The answers to these questions will help to provide needed understanding in order to quantify the contribution of society'e activities to global change and allow everybody, worldwide, to be prepared to act accordingly.

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Some questions that must be addressed are:

- What effects do societies have on global climate change compared to the natural forces of weather and the small (but real) natural changes in the atmosphere and weather as the planet grows older?
- What are the principal uncertainties in the scientific bases for global climate change predictions and the consequences of those uncertainties?
- What are the anticipated future distribution and sources of "greenhouse gases"? How might this mix be changed without undue economic, environmental, and social costs? Do those affected understand these costs?
- What is the likely range of effects on energy development? Is the importance of energy development, which enables us to produce the basic necessities and amenities of life, duly recognized?
- What can the rest of the world learn from the U.S. in order to achieve economic growth and well-being with virtually no increase in carbon dioxide emissions?
- Which of the many proposed mitigation strategies will be effective? How do we avoid wasting effort, much less doing the wrong thing?

The role of science in this issue is to provide direction and scope for policy development. However, a number of things should be done now, on a parallel track with the above scientific research efforts. Policy that

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makes sense on its own merits can be adopted now. And, when more is known, we will better understand what other actions to take.

The Chamber urges the U.S. immediately to lead the way to:

- Educate people around the world about global climate change and the choices that may be necessary to avoid it.
- Support international cooperative research to advance the ability to predict the effects of such change and take needed moves to alleviate or avoid them.
- Implement actions to mitigate climate changes caused by man and assure that they make economic, social, and environmental sense on their own merits.
- Assist developing nations in joining the global efforts while maintaining their economic growth by increasing research and development and trade incentives, and by sharing land and forest management and new agricultural practices, and by other means.
- Remove unnecessary impediments to the adoption of alternative energy technologies and energy conservation.

Unilateral actions also should be taken. They include:

- Encouraging more energy conservation.
- Striving to gain acceptance of nuclear energy.
- Exploring other alternatives to fossil fuels: wind power, photovoltaic cells, and solar collectors.

While embarking on the above, it is important that we not abandon established national energy and environmental policies in favor of those

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that may have profound unknown (and possibly negative) economic, social, and climatological effects. We must take care that our actions do not impose a wasteful and unfair burden on society.

Conclusion

Global climate change is neither a partisan nor a philosophical issue. The challange for everybody, worldwide, is to act accordingly, at the right time. The Chamber believes that its parallel track of research and action stratagies provides an appropriate balance between information gathering and steps that we can take now.

The Chamber appreciates this opportunity to present its views on S. 169 and to recommend strategies for research and action on global climate change. It looks forward to working with the Committee on Commerce, Science, and Transportation on this important issue.

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INTERNATIONAL MEASURES FOR THE PROTECTION OF THE OZONE LAYER

by

Louis B. Sohn
Woodruff Professor of International Law
School of Law, University of Georgia

Excerpt from Lecture made at a meeting of the Faculty of the Environmental Ethics Program of the University of Georgia, February 7, 1989.

. . . . . .

In 1974, two American scientists, F. Sherwood Rowland and Mario J. Molina published an article in Nature (249:810), calling attention to the destruction of the ozone layer by fully hallogenated alkanes (FHAs), the most important of which are the chlorofluorocarbons (CFCs). They are being released into the atmosphere in constantly increasing quantities. Later studies disclosed that, in particular, a rapidly growing hole has appeared in the ozone layer above the Antarctic, where an area of the size of the United States was depleted by up to fifty percent, and that there is a smaller hole also above the Arctic.

It was soon discovered that, for instance, the ozone-depleting chemicals were present in, and released from, fire extinguishers, cooling agents (such as freon) used in refrigerators and air conditioners, and propellants in aerosol cans. They were being used also in the process of manufacturing foam insulation (e.g., polystyrene plastic cups), and in cleaning

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solvents for computer microchips. Increasing use of nitrogen fertilizer throughout the world has led to a release of vast quantities of nitrous oxides which are also affecting the ozone layer.

(For a good short description of the problems associated with the ozone layer, see Sir Crispin Tickell, Climatic Change and World Affairs (University Press of American, Lanham, MD, 1986), pp. 27-30. See also Dennis Pirages, Global Ecopolitics (Duxbury Pass, North Scitnate, MA, 1978), p. 188.)

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Under the auspices of the United Nations Environment Program (UNEP) a conference held at Vienna in 1985 agreed on a framework Convention for the Protection of the Ozone Layer. It was based on the principle proclaimed in the 1972 Stockholm Declaration on the Human Environment that all States have "the responsibility to ensure that activities within their jurisdiction and control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction." Accordingly, the States Parties to the Vienna Convention agreed to take appropriate measures "to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer." They also decided to cooperate in the research, systematic

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observation and information exchange needed to better understand and assess the effect of various human activities on the ozone layer; and to formulate additional measures, procedures and standards for the implementation of the Convention, and to embody them in supplementary protocols to the Convention.

Some States were trying to obtain at Vienna an immediate agreement on a gradual reduction of the use and exports of CFCs in aerosols, and, to a lesser extent, of CFCs connected with other products. Other were willing to accept only a freeze on the production capacity, coupled with a minor reduction in annual use. The Conference recommended, therefore, that a working group should be established to prepare a protocol to control in an equitable manner the global production, emission and use of CFCs. Various proposals were soon presented to the working group, including one by Canada which envisaged the establishment of a ceiling (so-called global emission limit, GEL) on annual emission of all ozone modifying substances (OMS), and apportioning that total among the nations of the world, 25% in proportion to population and 75% on the basis of gross national product, so that each state would have a national emission limit (NEL).

The Vienna Convention took into account the special needs of the developing countries, and asked for the facilitation of the transfer to those countries of technology and knowledge, especially with respect to alternative technologies that might

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avoid the use of CFCs. The working group was obliged to consider the special problems of the developing countries, as many of them were rapidly increasing their use of CFC substances for refrigeration, food storage and nitrate fertilizers. The developing countries contended that their development and the need to feed their growing populations justified allocating to them an appropriate increase in imports of CFCs, especially as their use of those substances was dwarfed by the amount used by the developed countries. Nevertheless, the developing countries were willing to participate in implementing restrictions, provided they were assured an adequate period of adjustment, during which they would be still allowed the benefit of CFC products, pending the development of effective substitutes.

In the summer of 1987, the World Commission on Environment and Development, the so-called Brundtland Commission, established as an independent group by the United Nations and chaired by the prime minister of Norway, Mrs. Gro Harlem Brundtland, presented a report on Our Common Future (Oxford University Press, Oxford - New York, 1987), which emphasized that global problems of environmental degradation would have to be solved in the context of economic development. The report noted the widening gap between rich and poor nations, the continuing growth of world population, the increasing concentration of people in urban areas, and the mounting demands for food and energy. At the same time, the report described the environmental trends that were

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threatening to radically alter the planet, thereby endangering the life of many species upon it, including the human species. It mentioned the cumulative effect of destruction of forests, acid precipitation, global warming caused by fossil-fuel burning, the industrial toxic waste invading the underground water supplies, and - last, but not least - the threat to the stratospheric ozone layer. Throughout, the report stressed that these were not separate crises - an environmental crisis, a development crisis, and energy crisis - but there were all one. In particular, it emphasized, the developing countries were facing a resources gap and a life-threatening environmental crisis, made worse by the industrial world having used up much of the planet's ecological capital. This inequality between the haves and the have nots was simultaneously the planet's main "environmental" problem and its main "development" problem. The report contained many recommendations, which emphasized the ecological dimensions of policy decisions, and the need for governments, international institutions and multinational companies to develop longer-term development objectives than they were willing to do at present. Those objectives must take into account not only growth and social goals, but also environmental impacts.

The General Assembly of the United Nations approved by a consensus resolution (GA Resolution 42/187), without a vote, the main findings and recommendations of the World Commission. The

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General Assembly recognized that sustained development requires "meeting the needs of the present without compromising the ability of future generations to meet their own needs," and that, in particular, the key to sustainable and environmentally sound development is "an equitable sharing of the environmental costs and benefits of economic development between and within countries and between present and future generations." It added that environment and economics must be merged in decision-making, and that developing countries should be assisted by both the developed countries and the United Nations in developing and enhancing "their capacity for identifying, analyzing, monitoring, preventing and managing environmental problems," and for integrating them into national development plans, priorities and objectives.

At the same time, the General Assembly adopted (by Resolution 42/186) the "Environmental Perspective to the Year 2000 and Beyond," as "a broad framework to guide national action and international co-operation on policies and programmes aimed at environmentally sound development." It welcomed, as the overall goal for the international community, "the achievement of sustainable development on the basis of prudent management of available global resources and environmental capacities and the rehabilitation of the environment previously subjected to degradation and misuse." The Environmental Perspective noted (in para. 39), inter alia, that "[i]ndustrial production and emission

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of chlorofluorocarbons threatens a significant depletion of the ozone layer, leading to increased ultraviolet radiation," and recommended (in para. 47 (1)) specifically the conclusion of "agreements on the reduction of ozone-depleting substances."

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[The working group established by the United Nations Environment Program (UNEP) after the 1985 Conference, after six tries and difficult negotiations completed in 1987 a generally acceptable draft of an international protocol dealing specifically with substances that deplete the ozone layer. It was approved on September 16, 1987, by a conference held in Montreal and attended by more than 60 countries.] Its purpose was to take precautionary measures to control equitably total global emissions of these substances, in preparation for their later elimination. That elimination would depend on the development of scientific knowledge and technology, and would have to take into account both technical and economic considerations, as well as the needs of developing countries for these substances until adequate substitutes would become available.

It was agreed that the Protocol will come into force upon its ratification by at least eleven States (or regional economic integration organizations such as the European Economic

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Community), representing at least two-thirds of the 1986 estimated global consumption of the controlled substances. Upon the coming into force of the Protocol, and after a grace period of six months, each Party to the Protocol would be obliged to restrict its annual consumption of a group of controlled CFC products to the level of its consumption in 1986, and each Party producing such products would be obliged to restrict their production to its production level in 1986, except that it might increase such production by 10%, but only for the purpose of satisfying during a transition period of ten years the basic domestic needs of Parties that are developing countries and use annually less than 0.3 kilograms per capita of the controlled substances. Three years later another group of controlled products (the halons, which contain bromine and are even more dangerous to the ozone layer than chlorine, but which are used in lesser amounts than CFCs, mostly for fire extinguishers) would become subject to a freeze at the 1986 level. As the Protocol came into effect on January 1, 1989, each Party would be obliged to cut down in July 1993 its consumption of the first group of controlled products by 20%, and its production also by 20% (subject to the 10% supplement for the benefit of developing countries). Similarly, a further cut of 30% in consumption and production of the first group of controlled substances would take place in July 1998 (subject this time to a 15% supplement for the benefit of developing countries). But this second cut might be cancelled by a two thirds majority of the Parties representing at

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least two-thirds of the total calculated level of consumption of this group of controlled substances, provided that such action is justified by an assessment by special panels of experts of available scientific, environmental, technical and economic information. Should the ozone-depleting potential of some CFCs be reassessed, additional reduction in production quotas might be made, preferably by consensus, but if necessary by a two-thirds vote of the Parties representing at least fifty percent of the total consumption of the controlled substances of the Parties. The list of controlled substances might be also changed, by adding or removing substances, by a two-thirds majority vote of the Parties.

A prohibition of imports of controlled substances from a State not party to the Protocol would come into effect one year after entry into force of the Protocol, and a prohibition of exports to such a State would come into effect in 1993. Prohibitions would be established at various dates for imports from States not parties, first, of products containing controlled substances, and, later, of products produced with, but not containing such substances. Restrictions would also be imposed on exporting to States not parties of technology for producing and for utilizing controlled substances, and on facilitating exports to them of products, equipment, plants or technology that would facilitate the production of controlled substances.

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Machinery would be also established for the implementation of the Protocol, including measures to be taken against Parties found to be in non-compliance with the provisions of the Protocol.

The Protocol, signed promptly by twenty-five nations, including the United States, has been hailed - by the Canadian Environment Minister Thomas McMillan - as "a historic first," namely "a law of the atmosphere that deals with extremely important planetary problems." He added that thereby we have gained time to prevent disaster, provided we act promptly, but noted that a "planetary time bomb is ticking away and the pace is accelerating." (Canada Reports, Winter 1987-88, p. 21.)

New findings, released in March 1988 by the U.S. National Aeronautics and Space Administration (NASA), indicated that the ozone layer has been depleted by up to 3% since 1969, instead of 1% assumed by the experts who prepared the Montreal Protocol. One result might be an increase of 6% to 9% in the amount of ultraviolate radiation reaching the surface of the Earth. Proposals soon followed, to accelerate the reductions in the production and consumption of the CFCs, if necessary even by unilateral steps.

Coincidentally, preparations have started for the Stockholm II Conference in 1992 (the 20th anniversary of the 1972

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Conference on Human Environment), and a group of Eastern European countries has suggested that the 1992 Conference should adopt either a Universal Declaration or a Convention on Environmental Protection based on the concept of "ecological security" and embodying a system of norm-setting, organizational and material measures, that would provide a framework for safeguarding and preserving the environment and improving its quality with a view of "creating appropriate conditions for a life worthy of human beings and securing sustainable and safe development of all States." (U.N. Doc. E/1988/105.)

Some twenty years ago, the small Mediterranean State of Malta proposed that the United Nations should declare that the resources of the deep seabed are the common heritage of mankind, and that proposal led to the United Nations Convention on the Law of the Sea which codified the law on the subject. In 1988, Malta came back with a proposal to declare that climate is a part of the common heritage of mankind, because of the urgent need to conserve climate in the interest of mankind by protecting it against negative man-made changes, which are seriously disturbing the balance of nature. Malta also proposed the establishment of an inter-agency mechanism to elaborate "a global strategy to conserve climate in order to ensure that life on Earth can be sustained." (U.N. Doc. A/43/241.) As the Maltese Foreign Minister, Vincent Tabone, stated in the General Assembly (43 GAOR, 35th Plenary Meeting, October 24, 1988):

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> The conservation of the global climate system ... cannot be left to individual States unilaterally to decide what, if any, conservation measures should be taken. The fundamental human right to life and the need to conserve climate as one of the prerequisites of human life cannot be limited by political boundaries and therefore requires an international strategy which transcends state sovereignty in the interest of present and future human generations.

Some countries immediately objected to applying the concept of common heritage of mankind to climate, but there was a general consensus that common action is needed to save the climate of earth and to achieve ecological (or environmental) security, and that such action may require the elaboration of legal instruments concerned with climate. As the United Kingdom's Ambassador to the United Nations, Sir Crispin Tickell noted at the same General Assembly meeting, the Montreal Protocol, establishing controls on CFCs was not only a first step to preserve the ozone layer but also an important step to reduce the effect of these powerful gases on the global warming, the so-called "greenhouse effect." He added that even more drastic steps were needed to limit atmospheric carbon-dioxide through reducing the burning of fossil fuels, such as coal and oil. It was pointed out, however, by other delegates that another crucial element, deforestation, cannot be stopped unless the hard-core poverty in developing countries could also be resolved.

. . . . . .

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After 15 days of intensive discussion, the Second Committee of the General Assembly, without a vote, adopted and submitted to the General Assembly in November 1988 a detailed resolution (U.N. Doc. A/43/905, p. 5-8) noting, inter alia, that "climate change affects humanity as a whole and should be confronted within a global framework so as to take into account the vital interests of all mankind." Without using the controversial phrase "common heritage of mankind," the General Assembly recognized that "climate change is a common concern of mankind, since climate is an essential condition which sustains life on earth." The General Assembly also approved a plan of action, leading as soon as possible to a comprehensive review and recommendations with respect to:

(a) The state of knowledge of the science of climate and climatic change;

(b) Programmes and studies on the social and economic impact of climate change, including global warming;

(c) Possible response strategies to delay, limit or mitigate the impact of adverse climate change;

(d) The identification and possible strengthening of relevant existing international legal instruments having a bearing on climate;

(e) Elements for inclusion in a possible future international convention on climate.

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The Assembly also endorsed the joint action by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO), which at the end of 1988 had convoked an Intergovernmental Panel on Climate Change (IPCC). That panel promptly established three working groups: a scientific one - to collect the data, to assess the scientific evidence and to map out the trends; an economic and social one - to analyze the economic and social impact of the climate changes on various groups of states; and a political one - to look at the policy responses that need to be recommended. It is expected that as the results of these studies become available, it would be possible to follow the method adopted with respect to the ozone layer and to prepare first a framework convention establishing not only some general principles relating to the human activities that are causing the climate changes, but also outlining the steps that would have to be taken to manage them globally and equitably. For instance, if, in order to limit the emission of carbon dioxide, it would become necessary to establish a "global carbon budget," it might be agreed that those who have in the recent past contributed a major share of the greenhouse gases to the atmosphere should make a larger response than those who might be contributing more at present. Such an equity factor might have to be built into many of the policy responses that would have to be taken. One problem would have to be tackled after another, and a series of protocols properly tailored to each situation would be adopted. This program was endorsed by the

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General Assembly at the end of 1988, and 1992 might become the first target date. (UN Radio, Perspective '88, Nos. 46-47, Conservation of Climate as Part of the Common Heritage of Mankind.)

To assist in this international effort, Senator Hollings introduced on January 25, 1989, the National Global Change Research Act which would establish a framework for the development of a 10-year national global change research plan that would coordinate federal research on greenhouse warming, the rapid depletion of the earth's protective ozone layer and other long-term environmental changes. It can be expected that the efforts of the United States will be properly coordinated with those of the competent United Nations agencies, enabling all concerned to work toward a common goal.

After a long period of inaction, the pace has accelerated, and a new environmental ethos is quickly developing, based on the principle that the present generation has a responsibility to leave to next generations not a burnt out piece of rock, but a flourishing green planet, full of life, liberty and pursuit of happiness.

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IMPLICATIONS OF CLIMATE CHANGE FOR THE INSURANCE INDUSTRY

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PURPOSE

For contingency planning purposes of insurance, emergency planning and hazard mitigation activities, it is prudent to attempt to ascertain the potentiality for sizeable changes in the production and severity of storm-caused natural disasters due to a Greenhouse-induced warming trend in the near term (immediately upcoming years) in addition to that in the longer term (upcoming decades). The future production and magnitude of weather-caused natural disasters in the United States would be very sensitive to a significant Greenhouse- induced warming that could occur near the end of the next half century. There is also a current need to ascertain if some sensitivity could even occur during the transitional climate phase, in the next decade or so, when lesser amounts of warming associated with the upward trending in global atmospheric temperature would take place.

An attempt has been made to quantify these potential near-term effects, utilizing presently available information that is consistent with the current state of knowledge about natural disasters caused by storms; regional storm characteristics (frequency, severity, location); and likely effects of a global atmospheric warming on these storms and their catastrophe-producing potential. Unfortunately, detailed implications regarding possible Greenhouse influences on regional storm characteristics (frequency, severity, location) based on global climate model simulations will not be available in the near future. Consequently, any inferences that presently can be made must be based indirectly on less pertinent and less credible information from other sources.

APPROACH

The approach was to determine the catastrophe production of various storm types in the present climatic regime and then to estimate changes attributable to a Greenhouse warming trend. Reference 1 provides details of the analysis. The representation for the present climatic period was based on an analysis of 800 weather events that occurred over the past 40 years which caused large amounts of insured damages and, as a result, were coded as weather-caused catastrophes by the insurance industry. The damage-producing potential of a recurrence in 1989 of each of these events to currently insured properties was simulated. Each recurrence would have caused at least $5 million in losses. Cause of loss was used as a criterion for grouping the catastrophes into one of three storm type categories: winter storms, hurricanes, severe local storms (thunderstorm-spawned perils of tornadoes, hail, and "straight-line" winds). Damage to "fixed properties" such as buildings, caused by inland and coastal flooding including storm surge is not a part of the catastrophe totals because this peril is primarily covered by National Flood Insurance, a federal program. Storm regions were defined.

Catastrophe production characteristics of each storm type during the present climatic regime were determined and summarized in Table 1. The number and magnitude of these events were grouped by day and month of occurrence so that the seasonal variation in catastrophe production could

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be determined for each storm type. An objective is to examine possible effects of a Greenhouse-induced warming trend in the near term which is defined to be a period of climatic transition extending from the present to ten years after the turn of the century (1990-2010). This interval would represent the changeover period between present climate conditions and those of a much warmer atmospheric environment (2010-2050) if the full effects of a Greenhouse warming are realized.

Table 1. Estimated total 1989 damages by storm type, resulting from a repeat of each of the catastrophe-coded weather events that have occurred in the past forty years and which would cause at least $5 million in damage to presently insured properties in the United States.

	Present Climatic Regime				
Storm type	Number of Catastrophes	Percentage	Total Damage Production (billions of dollars)	Percentage	Average Annual Damage Production
Hurricane	51	6.4	27.2	40.2	$ 680,000,000
Severe local storm	649	81.2	31.4	46.4	780,000,000
Winter storm	99	12.4	$ 9.1	13.4	230,000,000
Total	799	100.0	$67.7	100.0	$1,690,000,000

Regional temperature changes that would probably occur sometime during the transitional climate period have been used: hurricane region, +0.5°C (+0.9°F) in sea surface temperature; severe local storm region, +1.0°C (+1.8°F) northern sections and +0.5°C (+0.9°F) in southern sections in air temperature; winter storm, +1.0°C (+1.8°F) in air temperature. These increases are consistent with output of global climate model simulations reported in the scientific literature. Timing of the year of occurrence of the increases would depend on how the Greenhouse effect interacts with other sources of global atmospheric temperature variation. The effects of these assumed regional increases in average temperature upon the catastrophe production of each storm type were estimated by converting the temperature changes into a measure of the implied expansion or contraction of the seasonal distributions of the number and severity of catastrophes produced by each of the storm types.

Differences in the size and shape of these distributions between present climate and transitional climate conditions were used to denote the probable effects of a Greenhouse warming on catastrophe production. In the period of climatic transition, seasonal changes in the atmospheric circulation are assumed to be close to those of the present climate except that these changes would occur at a somewhat earlier date in the spring and a slightly later date in the fall. In effect, the characteristics of storm activity in the transition period would be similar to that in the present climatic period with a slight shift in time of occurrence. As a

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result, intervals of maximum activity could be shortened or extended depending upon storm type and season of occurrence.

HURRICANES

Seasonal changes in sea surface temperatures (SST), which were utilized as a climate change index for the hurricane region, would be much larger than the anticipated increase due to a Greenhouse warming during the period of climatic transition. Exhibit 1 illustrates seasonal variation under present climatic conditions. For reference, it is noted that tropical cyclones usually do not form when the sea surface temperature is less than about 80° Fahrenheit, even though atmospheric conditions are favorable for storm development. Areas with sea surface temperatures of 80°F or above are represented by double stipled areas in Exhibit 1. Exhibit 2 represents a typical seasonal sea surface temperature curve for specific locations in the hurricane region. The horizontal line on the chart denotes the approximate minimum sea surface temperature for tropical cyclone development. The intersection of this line with the sea surface temperature curve roughly defines the beginning and ending times of the tropical cyclone season (late May and late November). Refer to Exhibit 3.

It is assumed that during the transitional climatic period, the effect of a Greenhouse-induced upward trend in surface air temperature over the hurricane region will result in an eventual increase in sea surface temperature over the same area after an appropriate time lag of at least a year (Exhibit 4). The upward shift in the seasonal sea surface temperature curve, when an increase of +0.5°C (0.9°F) is added to the seasonal curve representing the present climatic period, is shown in Exhibit 5. This increase of +0.5°C, in effect, would lengthen the tropical cyclone season as illustrated by the new location of the intersection of the modified sea surface temperature curve with the horizontal line representing the threshold temperature for tropical cyclone development. The overall length of the hurricane season would be increased by about 20 days.

The seasonal distribution of landfall dates of the 240 hurricanes is shown in Exhibit 6. There is a correspondence, although not necessarily a direct cause-effect relationship, between the seasonal variation in sea surface temperature and the number of hurricanes that cross the coastline of the United States (landfalling hurricanes). Because it is assumed that seasonal changes in the atmospheric circulation patterns will also shift slightly, the frequency distribution of the number of landfalling hurricanes, in effect, would be split into two segments at the time of highest sea surface temperatures. The early summer segment would move the equivalent of about 10 days toward earlier occurrence times. The late summer segment would shift about 10 days toward later occurrence dates. The result of these shifts would be an addition to the landfall frequency distribution of a period of about 20 days, during the time of highest sea surface temperatures, when more landfalling storms could occur. These occurrences would be over and above the ones experienced during the present climatic regime. This additional increment to the landfall frequency distribution, which is depicted by the crosshatched area in

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Exhibit 7, represents an increase of about 33 percent in the annual number of landfalling hurricanes between the present and sometime during the period of climatic transition.

A plot of the number of times in the past 117 years that the estimated maximum winds of hurricanes at landfall attained given values suggests that there is a correspondence between the seasonal sea surface temperature and the occurrence of hurricanes of severe intensity (Exhibit 8). The higher the temperature, the greater the likelihood that the storm will be of stronger intensity. Similarly, a comparison between the percentage of September hurricanes (when the sea surface temperatures are near maximum) with that of non-September hurricanes also suggests a correspondence, although not necessarily a cause-effect relationship, between the seasonal sea surface temperature and the probable landfall location of an incoming hurricane. September storms are more likely than non-September storms to have a landfall on the Atlantic coastline and also to be more severe (Exhibit 9). This combination of storm intensity and landfall location is of importance to insurers because of its influence in the determination of whether a coded catastrophe will be produced and, if it does occur, what its resultant magnitude is likely to be.

Magnitudes of the coded catastrophes caused by hurricanes are closely related to both the physical characteristics of the storm and its path relative to coastal and inland concentrations of insured properties. Exhibit 10 graphically illustrates this interaction of the high wind speed pattern of a passing hurricane with the spatial distribution of insured properties. Coastline exposures, where the highest winds occur, are especially susceptible to damage (Exhibit 11). Computer simulation techniques can be used to approximate the damage-producing potential of a hurricane to a spatial array of properties (Exhibit 12). This approach was used to establish a benchmark measure of the catastrophe production by hurricanes of the present climatic regime using the entire hurricane climatology of 240 landfalling storms (1871-1988).

These present-day damage potentials which are based on a simulated recurrence of each of the 240 events, have been accumulated by date of landfall. The resulting frequency distribution of aggregate hurricane-caused loss potentials by date of occurrence is shown in Exhibit 13. A comparison with the seasonal sea surface temperature curve, which is also plotted on the chart, indicates that the largest amount of damage potential occurs during that portion of the hurricane season when sea surface temperatures are at a maximum. A 20-day extension of the hurricane season during the period of highest sea surface temperatures creates a combination of increased number and severity of hurricanes with landfalls that are at or near coastal concentrations of insured properties. This situation increases both the likelihood and probable magnitude of insurance industry coded catastrophes caused by hurricanes. It could increase the annual average loss expectancy due to hurricane-caused coded catastrophes by 40 percent over those expectancies in the current climatic regime.

SEVERE LOCAL STORMS AND WINTER STORMS

A Greenhouse-induced temperature increase could cause a time shift in seasonal activity of severe local storms which might reduce their damage producing potential by elimination of those catastrophes that occur during a two-week period centered at the midpoint of the cold season.

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This shift in the timing of the storm patterns could result in an annual reduction in severe local storm damage production of about $5 million. However, the extension of severe local storm activity by an additional two-week period in midsummer because of the slight seasonal shift could contribute an annual increase of approximately $30 million per year. The net change in severe local storm catastrophe production between the present climate and transitional climatic regime would be an additional $25 million annually.

Contraction of the winter storm season could lead to an elimination of about two weeks of maximum storm activity near midseason in January. The average annual reduction in catastrophe damage production due to winter storms would be about $20 million per year.

OVERALL INCREASE IN CATASTROPHE PRODUCTION

Table 2 lists the resultant increases in damage production.

Table 2. Estimated change in the annual damage-producing potential of insurance industry coded catastrophes caused by the insured perils of wind and hail between the present climatic regime and an undefined time during the transitional climate period (1990-2010) when a projected warming due to the Greenhouse effect might be attained. Damage potential is expressed in 1989 dollars.

Storm type	Annual Damage based on Present Climatic Conditions	Change in Annual Damage Potential	Annual Damage based on Transitional Climate Conditions
Winter storm	$ 230,000,000	-$ 20,000,000	$ 210,000,000
Hurricane	680,000,000	+ 270,000,000	950,000,000
Severe local storm	780,000,000	+ 25,000,000	805,000,000
Total	$1,690,000,000	+$275,000,000	$1,965,000,000

The increase in the annual damage production of nearly $300 million represents a 30 percent increase over the insurance industry's current annual catastrophe loss based on an average over the past 3 years. Because of the large variability in the magnitude of individual catastrophes, the estimate of the average annual loss varies widely from one small sample to another. Over the past six years, the average annual loss is $1.6 billion. An estimate of a long-term average based on 40 years of experience is $1.7 billion as shown in Table 1. Using this estimate of annual damage for the present climatic regime results in about a 20 percent increase for the period of climatic transition.

CHANGE IN DAMAGE EXPECTANCIES DURING THE TRANSITIONAL CLIMATIC PERIOD

Table 3 lists the probable timing of increasing damage potentials during the transition period if the projected levels of regional warming are attained.

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Table 3. Approximate timing within the transitional climatic period when various changes in damage potential relative to that of the present climatic regime might take place if assumed levels of Greenhouse-induced global atmospheric warming are realized. Increases are expressed in 1989 dollars.

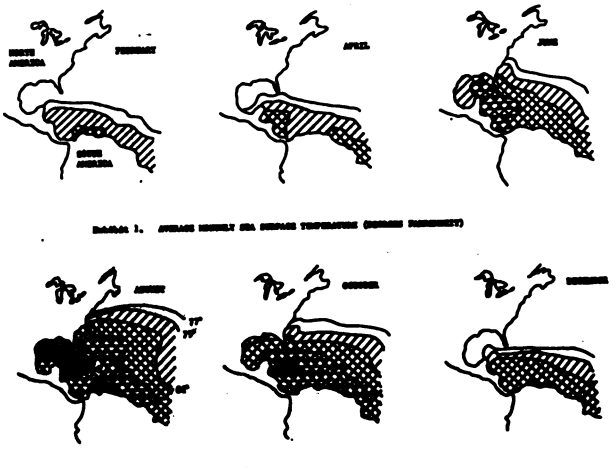
Time Interval Year	Increase in Annual Damage Potential of Weather-Caused Catastrophes Over That of the Present Climatic Regime	Approximate Percentage Increase Over Present Climatic Regime
1995-1999	+$150,000,000	10%
2000-2004	+ 300,000,000	20%
2005-2010	+ 500,000,000	30%

CONCLUSION

This attempt to obtain "order-of-magnitude" estimates of possible near-term changes in weather-caused catastrophe production, which are caused by a Greenhouse warming trend, is based upon the meagre amount of pertinent information that is currently available. Results are subject to major modifications as more credible data is developed.

REFERENCE

1. Friedman, D.G., 1989, Implications of Climate Change for the Insurance Industry, Travelers Insurance Company, Hartford, Connecticut, 44 pages.



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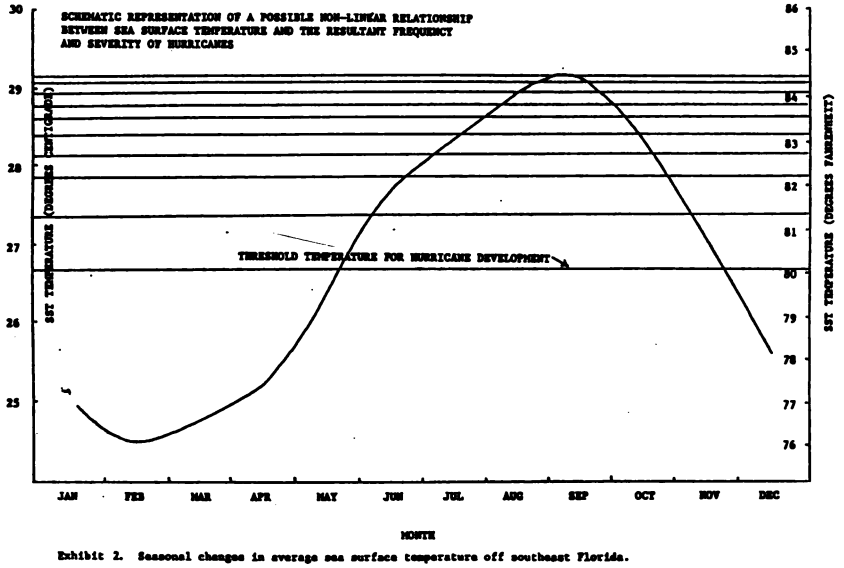

Exhibit 2. Seasonal changes in average sea surface temperature off southeast Florida.

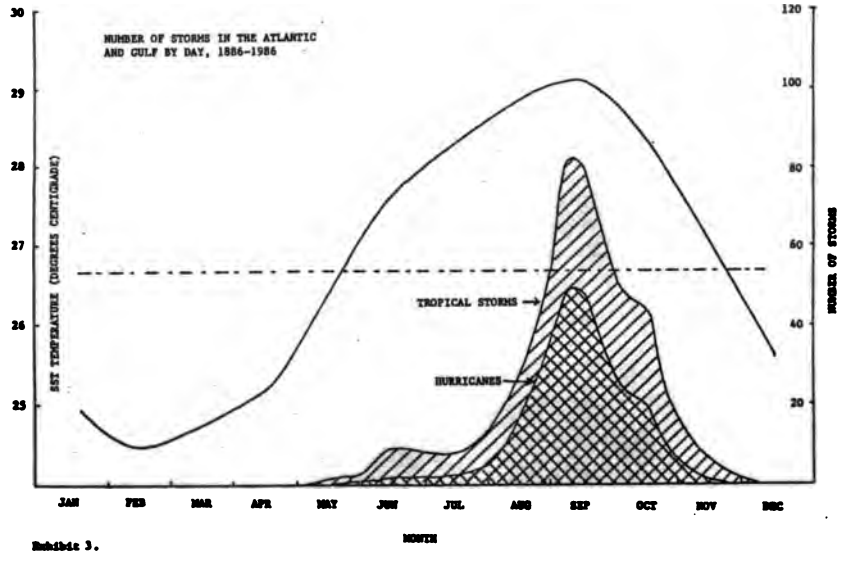

Exhibit 3.

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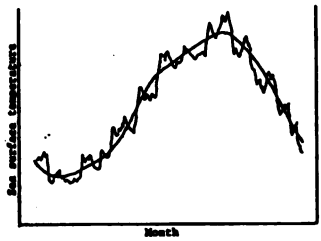
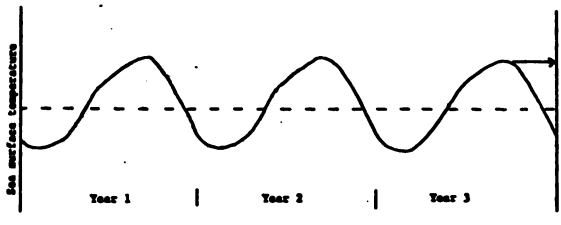
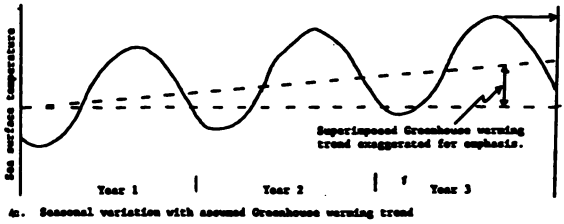


4a. Natural year-to-year temperature fluctuations average out over time to produce a smoothed seasonal variation.



4b. Seasonal variation with no temperature trend



4c. Seasonal variation with assumed Greenhouse warming trend

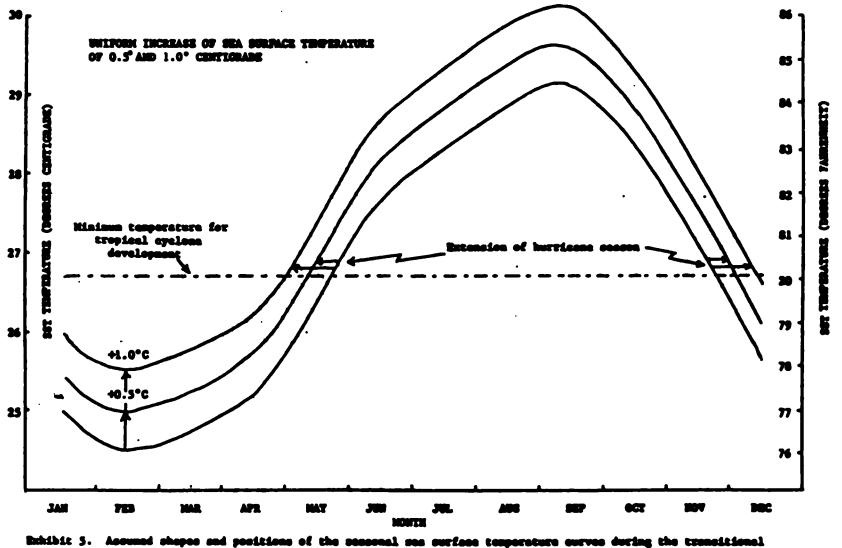


Exhibit 5. Assumed shapes and positions of the seasonal sea surface temperature curves during the transitional climatic period when Greenhouse warmings of +0.5°C and +1.0°C are added. Refer to Exhibits 1b and 1c for addition process.

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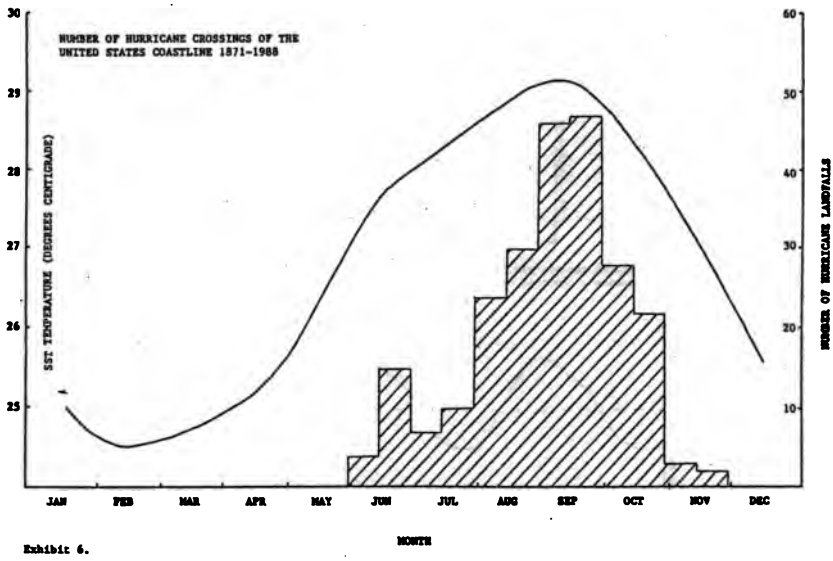

Exhibit 6.

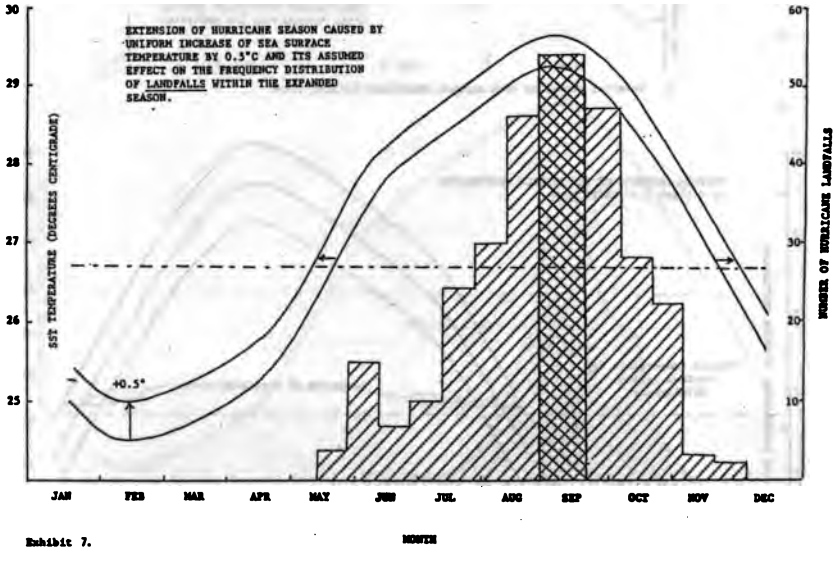

Exhibit 7.

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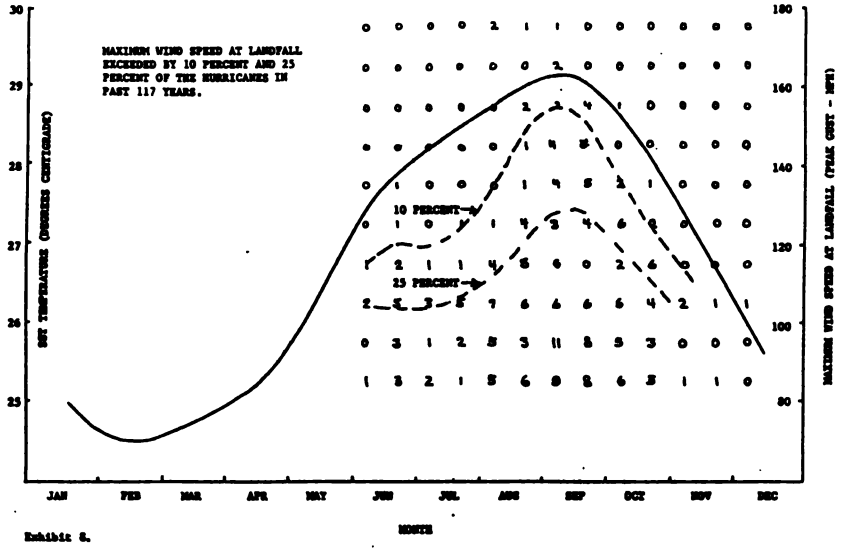
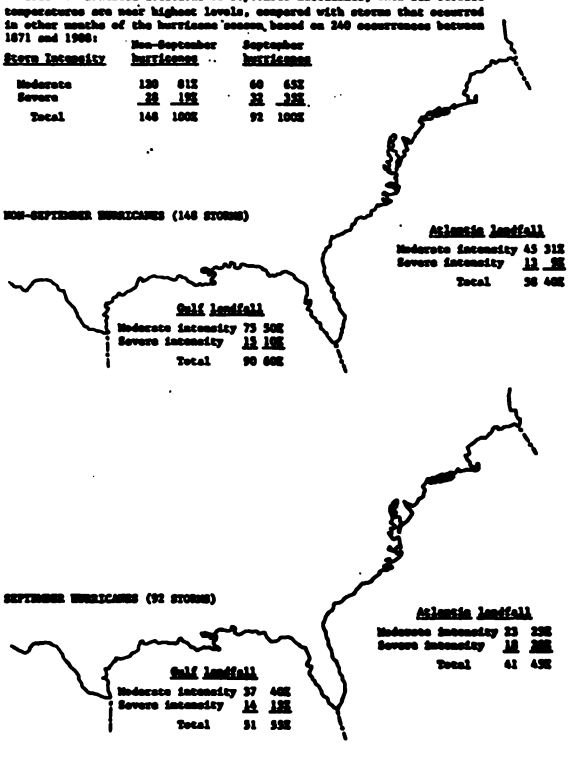

MAXIMUM WIND SPEED AT LANDFALL EXCEEDED BY 10 PERCENT AND 25 PERCENT OF THE HURRICANES IN PAST 117 YEARS.
10 PERCENT
25 PERCENT
SEA TEMPERATURE (DEGREES CENTIGRADE)
MAXIMUM WIND SPEED AT LANDFALL (TRUE GUST - MPH)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

Exhibit 8.

Exhibit 9. Landfall locations of September hurricanes, when sea surface temperatures are near highest levels, compared with storms that occurred in other months of the hurricane season, based on 240 occurrences between 1871 and 1968:

Storm Intensity	Non-September hurricanes		September hurricanes	
Moderate	130	81%	60	65%
Severe	28	19%	32	35%
Total	148	100%	92	100%



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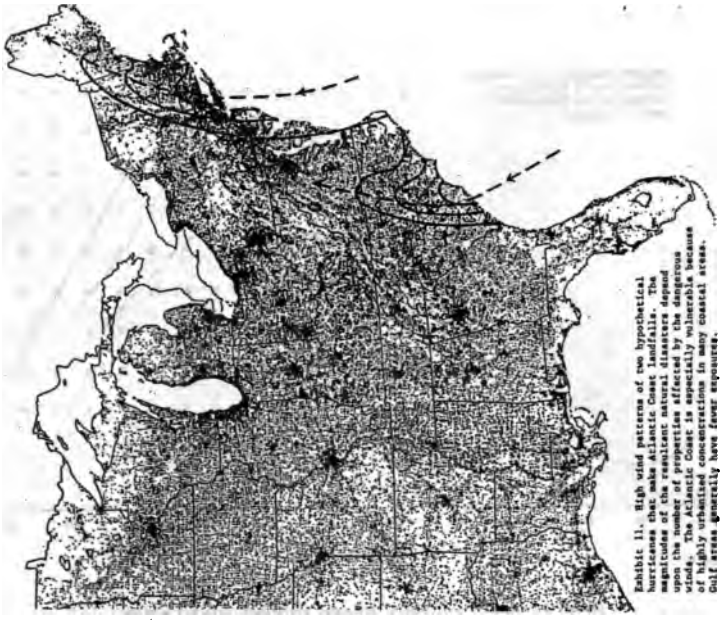

Exhibit 11. High wind patterns of two hypothetical hurricanes that make Atlantic Coast landfalls. The magnitudes of the resultant natural disasters depend upon the number of properties affected by the dangerous winds. The Atlantic Coast is especially vulnerable because of highly urbanized concentrations in many coastal areas. Gulf areas generally have fewer exposures.

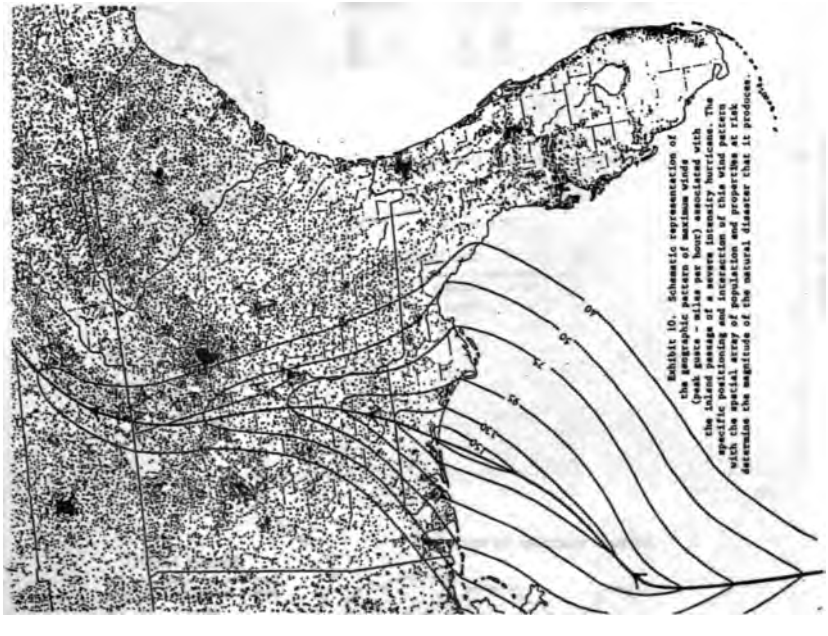

Exhibit 10. Schematic representation of the probable surface wind field associated with the inland passage of a severe intensity hurricane. The specific positioning and interaction of this wind pattern with the special array of population and properties at risk determine the magnitude of the natural disaster that it produces.

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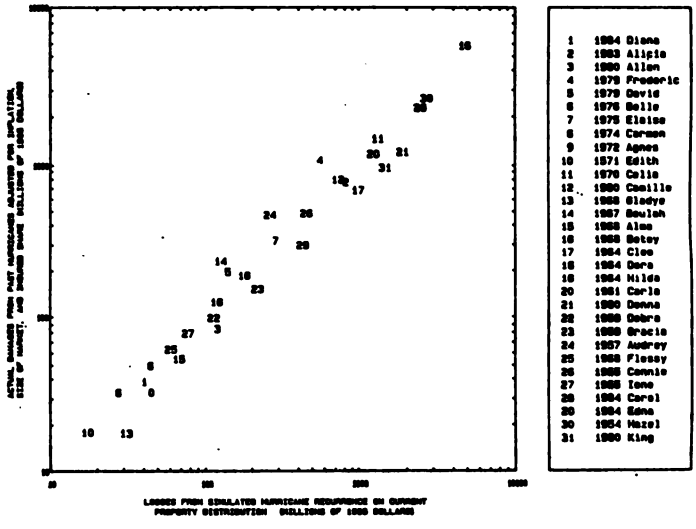

Exhibit 12. Example of the relationship between actual and simulated insured damages in hurricane-caused catastrophes that were coded by the insurance industry between 1930 and 1985. These results are plotted on a double logarithmic chart.

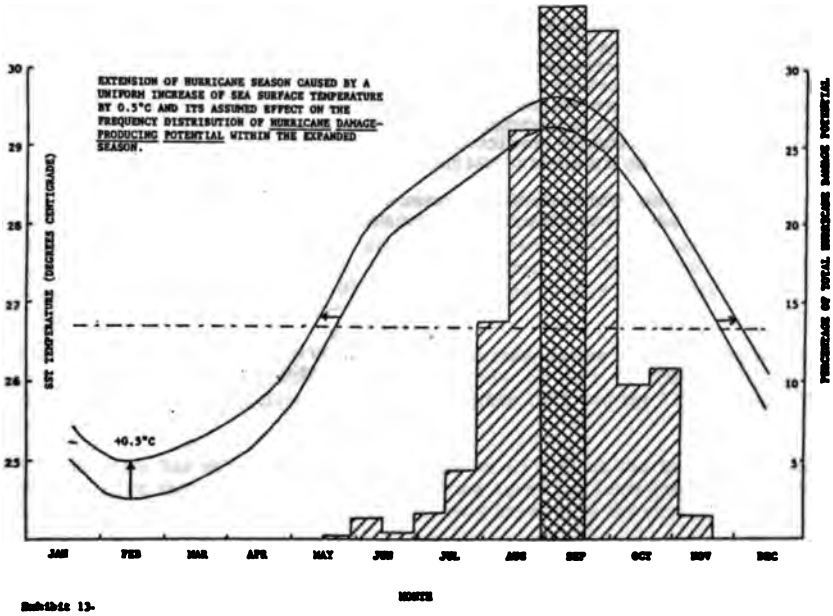

Exhibit 13.

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Office of the
Vice Chancellor for Research and
Dean of the Graduate School
(907) 474-7314

UNIVERSITY OF ALASKA FAIRBANKS
Fairbanks, Alaska 99775-1720

March 6, 1989

The Honorable Ernest F. Hollings, Chairman
Committee on Commerce, Science, and Transportation
U. S. Senate
Washington, D.C. 20510

Dear Chairman Hollings:

We commend the leadership your Committee has exercised in addressing issues of global climate change, and wish to underscore the role which the polar regions play in global change. The U.S. is recognized for its initiatives in the Antarctic. Alaska makes the U.S. an arctic nation, as well, and offers opportunities for important polar research.

At the high latitudes of our Alaskan arctic location, global change studies are particularly relevant for several reasons. Foremost among these is the fact that it is here where the signals associated with global change will be seen first, and where they will be seen with greatest magnitude. This is because feedback processes amplify the effects associated with snow and ice covers. Arctic ice sheets also serve as repositories of critical information on past climates, and are important because changes in the equilibrium of these ice masses affect global sea level, triggering social and economic reverberations around the globe.

Alaska is in a unique position because of its location, and because of the scientific strength of the University of Alaska Fairbanks, to exert national and international leadership in polar science and technology. It is the major arctic research institution in the United States, and is poised to assume leadership as a center of excellence in the high-latitude studies of the international global change research program. This program will take place over the next decade, and is likely to be the most important scientific research to be conducted before the end of the century. For reasons of both location and expertise, our state can serve both as an early warning system and as the test site for our policies. The university is prepared to make that commitment.

As you explore these issues during the 101st Congress, we are prepared to assist your deliberations in any way that may add to your information and ideas about global climate change.

Sincerely,

Luis M. Proenza
Vice Chancellor for Research and
Dean of the Graduate School

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February 24, 1989

The Honorable Ernest F. Hollings
Chairman
Committee on Commerce, Science
and Transportation
United States Senate
SD-508 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Hollings:

The Association of Home Appliance Manufacturers (AHAM), which represents the majority of manufacturers of refrigerators, refrigerator-freezers and freezers sold in the United States, has an interest in your Committee's February 22, 1989 hearing on global climate change and the greenhouse effect. Since we did not have an opportunity to appear at the hearing, we respectfully request that this letter be included in the official hearing record.

The manufacturers of household refrigerators and freezers are facing a Catch-22 situation.

The very substances they rely upon to produce highly energy efficient refrigerators and freezers -- chlorofluorocarbons (CFC-11 and -12) -- are being phased out through international agreement because CFCs are harmful to the earth's stratospheric ozone layer. At the same time, the Department of Energy (DOE) is proposing potentially drastic increases in energy efficiency standards for these basic home appliances.

To illustrate the relationship of efficiency increases to use of CFCs, please note that this industry increased its use of CFC-11 by 55% to achieve the 96% efficiency increase for refrigerators achieved since 1972 and the 77% increase for freezers.

This industry has relied for almost 50 years on CFC-12 as the basic refrigerant gas and more recently on CFC-11 as a blowing agent for foam insulation. Now, it is feared that both of these CFCs are not only harmful to the stratospheric

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ozone layer, but they also contribute to the greenhouse effect. Appliance manufacturers and CFC producers are committed to phasing out use of these chemicals as soon as is practicable.

However, the reality is that there are no known commercially available substitutes for CFC-11 and -12 with comparable energy efficiency capabilities which do not also potentially contribute to the greenhouse effect.

The Federal law (National Appliance Energy Conservation Act of 1987) already mandates very strict energy efficiency standards for 1990. This industry can meet those standards. What it cannot do is commit right now to meeting higher standards until it knows what the new CFC substitutes will be and what their impact on energy efficiency will be. Once it knows this, it will need time to redesign and retool to mass produce those products. (Keep in mind that we produced nearly 8.6 million refrigerators and freezers this past year.)

In short, the household refrigerator and freezer industry does not know today what it can use to meet new standards tomorrow.

Some people are urging DOE to impose very strict new energy efficiency standards on the industry for 1993, in part to avoid building more electrical generating capacity which may contribute to the greenhouse effect, and, if later the industry finds it cannot meet those standards, then Congress can provide legislative relief.

We do not think this would be fair, sensible or necessary, especially since DOE cannot reverse standards once promulgated.

This industry is actively exploring joint technology development efforts with the Environmental Protection Agency (EPA) and DOE to find the right CFC substitutes and accompanying technologies as soon as possible.

We have every reason to hope, and expect, that higher efficiency levels can be considered and adopted before the end of this century. Should substitutes be found sooner, rather than later, we would expect both the industry and the DOE to come together to review energy efficiency standards.

Lest you think this industry is too cautious, please realize that we are talking about major and revolutionary changes to a product that is found in every U.S. household, a product that Americans consider a daily necessity and have come to expect will safely and reliably store their perishable food for at least 15 years or more. Furthermore, these are products that represent over $3 billion in manufacturer sales -- over 28% of the home appliance industry's total annual sales.

Clearly, time is needed to do the research necessary to find substitutes for CFCs which do not contribute to the destruction of the earth's stratospheric ozone layer, and which do not exacerbate the greenhouse effect.

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Your bill, S.169, appears to be a reasonable approach in coordinating federal government research activities, and AHAM supports it. Clearly, much research will be needed in order to better understand the global climate change issue and help resolve it.

I respectfully request that this letter be made a part of the record of the Committee on Commerce, Science and Transportation hearings on global warming (S. 169), held February 22.

Thank you for giving us an opportunity to present our views.

Sincerely yours,

Robert M. Gants

Robert M. Gants
Vice President
Government Relations

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